sustainability

Systematic Review

Sustainability Indicators for Dairy Cattle Farms in European Union Countries: A Systematic Literature Review

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Abstract: The European cattle milk sector has rapidly intensified in recent decades. This trend has received widespread disapproval from the public, which highlights the many problems linked to intensification. To address these concerns, agricultural policies commonly impose an agroecological transition. In order to evaluate and monitor the degree of sustainability of dairy cattle farms over time, many sets of indicators have been proposed in recent years. However, these indicators have often referred only to specific aspects of sustainability or have been generically proposed for the entire agricultural sector, and therefore, they are not capable of capturing the peculiarities and the complexity of the dairy cattle sector. A systematic review of the scientific literature was carried out to obtain a complete picture of the indicators proposed for the European context. A total of 325 out of over 6700 papers were selected, and three pillars—environmental, economic, and social pillars—were explored. A total of 70 indicators were identified, which could help build a complete and less sectoral picture of sustainability than that proposed so far. A total of 22 indicators were associated with the environmental pillar, 18 indicators were associated with the economic pillar, and 17 indicators were associated with the social pillar, while 12 indicators were associated with two different pillars. With reference to the measurement methods, considerable variability was highlighted, which did not allow us to identify or propose unique methods for measuring each indicator.

Keywords: European Union countries; dairy cattle farms; multi-criteria assessment; sustainable production

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1. Introduction

The European milk sector plays an important role in the world's milk production; in fact, Europe accounts for more than 20% of the world cattle milk supply, reaching 155 million tons in 2021. Milk production in Europe has steadily increased in recent decades, in parallel with the reduction in the number of dairy farms and the increase in the number of dairy cows per farm [1]. In fact, from 2010 to 2020, the average size of dairy cattle farms increased from 38 to 58 cows per farm, and in 2020, about 80% of all European milk was produced on intensive farms, mainly located in lowland areas [1]. Intensive farming is the subject of criticism from public opinion, and among the main reasons for this are ecological, environmental, and animal welfare issues [2,3]. Even mountain areas, which account for 15% of the European agriculturally utilized area and which comprise the area where the dairy system is the most important sector, are undergoing a structural change in the agricultural sector with the intensification of production; productive specialization for tourism according to a "food neocolonialism" pattern [4,5]; or the abandonment of the activity [6,7]. Traditional small-scale mountain farms provide multiple ecosystem services from a sustainability perspective, such as the conservation of animal genetic resources, pollination, recreation, and a stand-in opposition to some aspects of intensive livestock farming, such as landscape degradation, biodiversity loss, and the loss of wildlife habitat [8].

The need to provide ecosystem services, to maintain production while making it more socially acceptable, and to reduce environmental impacts has led to the need to promote extensive farming at the community level as well [9], and to encourage a transition from the current production models to more sustainable ones, such as precision farming, multifunctional agriculture, and agroecology [10–13]. However, this transition is slow [12], partly because of the difficulty of having approaches and methods that comprehensively identify dairy farm sustainability whose holistic assessment should be the basis for strategies aimed at this new transition [14].

There are currently many sustainability certification standards. However, these standards are heterogeneous due to the differences in the interpretation of sustainability indicators [15]. In the past, many protocols with different approaches have been applied to assess the sustainability of dairy farms. Nguyen et al. [16] and Hassani et al. [17] assessed sustainability by considering mainly environmental aspects. De Otálora et al. [18] assessed the sustainability of dairy cattle and sheep farms broadly and multidimensionally by considering 37 indicators that were derived from only three published papers. Rios et al. [19] proposed a sustainability indicator for Colombian specialized dairy based on 13 papers from their bibliography. Recently, Zira et al. [20] pointed out that more studies are needed that consider the joint assessment of three pillars/dimensions of sustainability: environmental, economic, and social. In fact, the choice of indicators is often inadequate due to the absence and lack of consideration of certain indicators that are essential when discussing the sustainability of dairy cattle farms, such as animal welfare [21].

At the European Union level, comprehensive protocols have been established to assess the sustainability of the agriculture, aquaculture, and fisheries sectors. In 2014, the Food and Agriculture Organization (FAO) developed a list of useful indicators to assess the sustainability of food and agriculture systems (SAFA) [22]. Similarly, in 2019, the Global Sustainability Standard Board (GSSB) approved the Global Reporting Initiative (GRI) standard project to develop protocols with the aim of identifying and describing the most significant environmental, economic, and social impacts of several productive sectors. In particular, GRI 13, which contains the agriculture, aquaculture, and fisheries sectors, was approved in 2022 [23].

These standards were developed and created to be applied generically in all areas of the agricultural sector; therefore, they are poorly suited to fully describing the dairy sector and its peculiarities. At the same time, in 2022, the "DEXi-Dairy indicator handbook" was published [24]. This work proposes both the indicators necessary to assess the sustainability of dairy farms and the identification of the measures necessary to calculate the indicators themselves. However, this handbook refers only to specialized dairy farms, despite considering all three pillars, and the rating scales of the individual indicators are mainly based on expert opinions. To our knowledge and based on the current available literature, there are no studies that fully consider both the three pillars of sustainability and the characteristics of dairy farms in different production systems.

The aim of this study was thus to conduct a systematic review of the sustainability indicators for dairy farms at the level of the European Union, which is a useful contribution to a broad assessment of sustainability that considers both specialized and small-scale multifunctional dairy farms. The literature review process is detailed, along with the identification and aggregation of different indicators into three pillars of sustainability. Subsequently, the indicators are discussed, with particular emphasis on those associated with multiple pillars.

2. Materials and Methods

2.1. Review Process

Following the updated guidelines published by Page et al. [25], the scientific literature available in the Scopus database was reviewed. Scientific material published between 2014 and 2022 was considered. The search was conducted by considering the combinations of the following terms: (dairy OR milk) AND (cow* OR farm* OR system* OR cattle) AND (biodiversity OR welfare OR "ecosystem services" OR lca OR "life cycle" OR sustainab* OR Agroecology OR gwp OR "greenhouse gas" OR ghg) AND (evaluat* OR value OR emission* OR approach OR mitigation OR indicator* OR assess* OR impact* OR (multi* W/2 (criteria OR indicator* OR functional*)) OR (environment* OR economic* OR social)). A first analysis was conducted to compare the results of a generic string with a more specific one that was only linked to the dairy cattle sector. While the generic string, which did not include the terms "(dairy OR milk) AND (cow* OR farm* OR system* OR cattle)", led to 124,533 pieces of scientific material, the dairy string led to a total of 6751 international peer-reviewed studies. According to Arvidsson Segerkvist et al. [26], animal welfare is a multifaceted concept that, in some cases, falls within one or more dimensions of sustainability, while in other cases, it is not considered as such. Knowing this issue, we decided to include the term "welfare" within the initial string. The boundary search was narrowed to the affiliation countries that joined the European Union before Brexit.

A flowchart of the systematic literature review process is reported in Figure 1 (Supplementary Materials). From the initial 6751 records concerning the topic, 3262 records were removed, as they were carried out outside the European Union. A first screening by article title was conducted. During this first process, 3489 records were screened, and among these, 2515 were excluded because no useful indicators for assessing sustainability were identified. In the following second and third screenings, 45 records were excluded as reviews and 183 were excluded because of the following reasons:

- English was not the primary language (n = 33);
- The record was not a journal or an article (gray literature: dissertations, conference proceedings and reports, etc.; n = 140);
- The study was conducted in the United Kingdom after 2020 (n = 10).

After the fourth screening (abstract reading), a further 270 articles were excluded due to the fact that they were outside the scope of this study. Therefore, 476 papers were finally selected, downloaded, and analyzed after a full-text reading. Among these, a further 151 papers were excluded because they were unrelated to this study. After a full-text reading of the final 325 articles, we discerned the countries included in each study.

2.2. Indicator Selection and Aggregation

Within the selected studies, the main indicators used to assess the sustainability of dairy farms were considered. Given the need to fulfill the scientific gap regarding the nomenclature [26], we created a hierarchical tree structure for each pillar of sustainability and a hierarchical scale of the considered attributes. In this structure, the lower level was represented by the indicators that were subsequently aggregated into criteria and principles. Finally, through a process based on the guidance provided in the reference articles, the branches represented by the sustainability pillar (i.e., environmental, economic, and social) represented the highest hierarchical level of the tree.

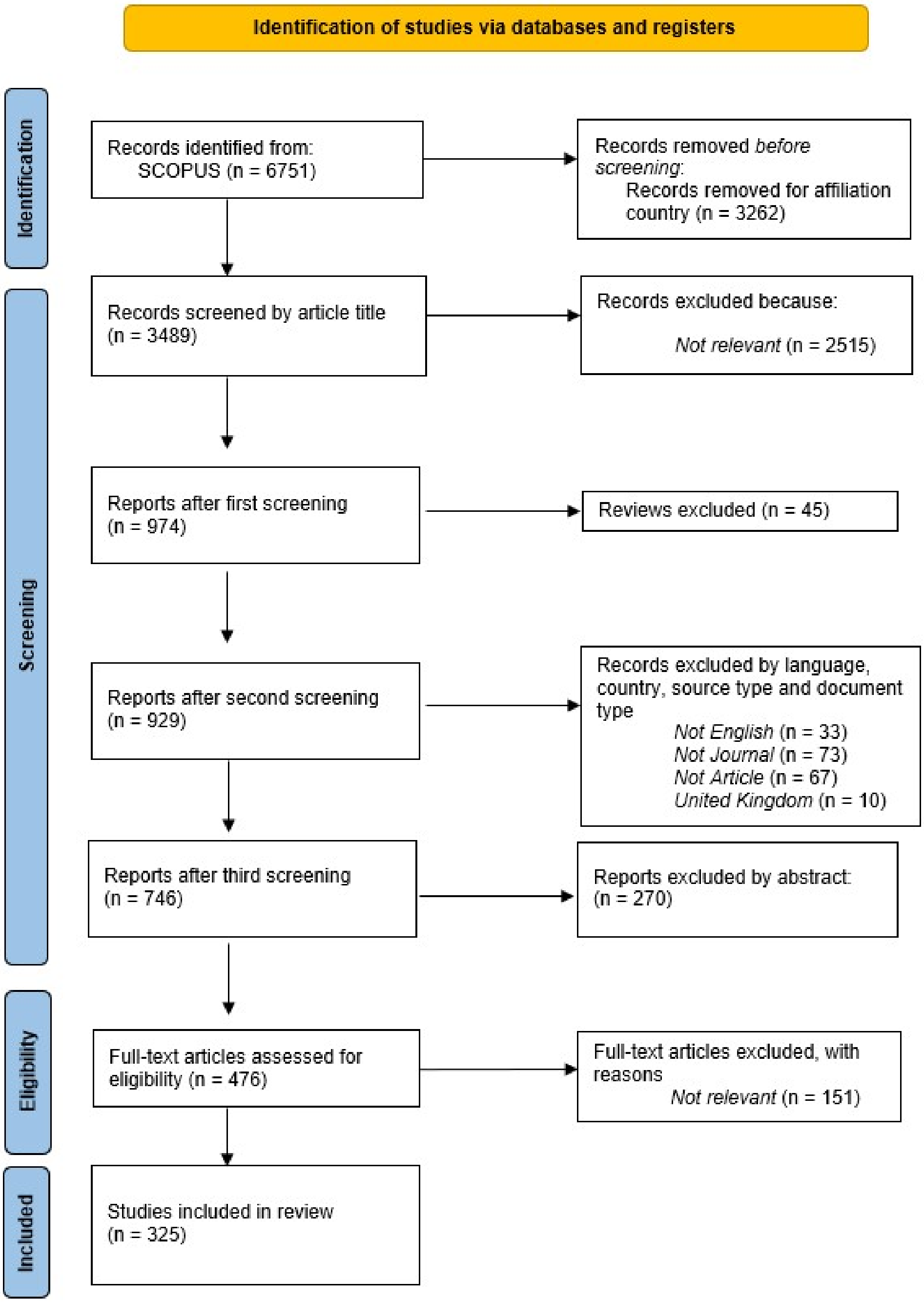

Figure 1. Flowchart of the systematic literature process.

3. Results

In Figure 2, the results for the countries included in this review are shown. Among these, Italy, with 66 papers, made up almost 19% of the overall studies, followed by Ireland, with 42 records (12% of the overall studies), and Germany, with 33 records (9% of the overall studies). No studies were reported for Cyprus or Malta.

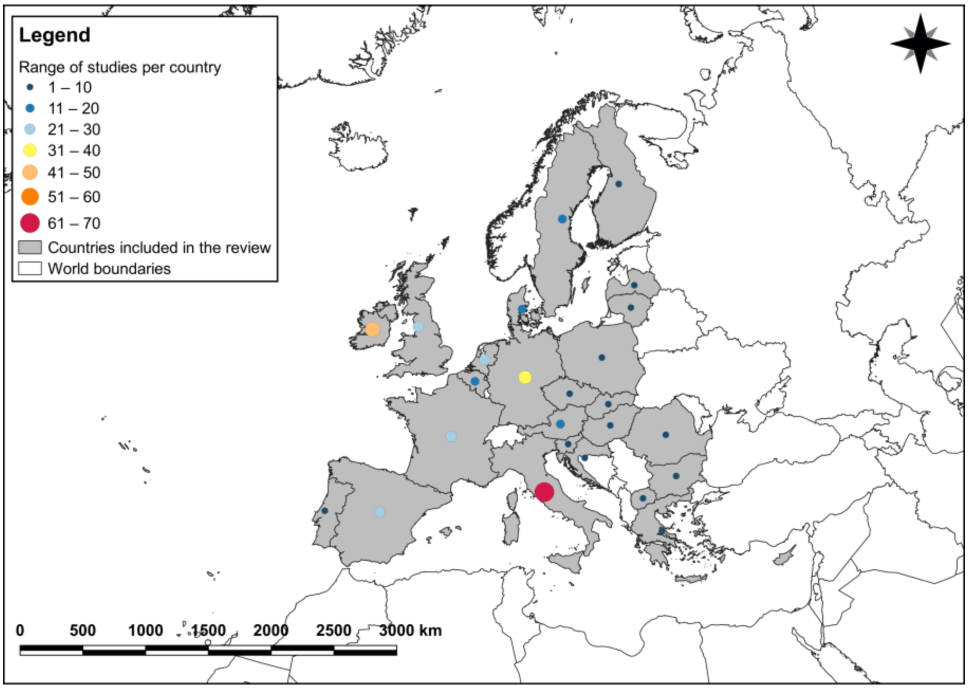

Figure 2. Countries included in the review and range of number of studies published in each country.

From the articles included in this study, 53% dealt with environmental sustainability, 6% with the economic dimension, and only 5% with the social dimension of sustainability. Among the 325 eligible manuscripts, 207 (64%) referred to a single pillar of sustainability, 51 (16%) considered two pillars, and only 17 (5%) included all three dimensions of sustainability. However, 15% of the scientific papers (50 records) included all three of the dimensions of sustainability previously discussed, since they dealt with the "animal health and welfare" topic.

Figure 3 shows the number of studies per country in which the three dimensions of sustainability were considered. The countries with a percentage of scientific publications higher than 0.6% of the overall considered studies included multiple pillars of sustainability. Conversely, countries with a percentage of scientific publications lower than 0.6% considered only one dimension of sustainability. The only exceptions were Bulgaria, which dealt with all three pillars in one publication (0.3%), and Portugal, which dealt with a single pillar (i.e., environmental sustainability) over five publications (1.54%).

Through the analysis, 70 indicators were identified, and these were divided into 26 criteria. The latter were grouped into ten principles that belonged to the three different pillars of sustainability: environmental, economic, and social (Table 1).

Different numbers of criteria were assigned to each dimension: seven criteria (26.9%) were assigned to both the environmental and economic dimensions, while six criteria (23%) were assigned to the social dimension (Figure 4). Only one criterion (3.8%) was shared between two dimensions (i.e., social and economic), while three criteria (11.5%) were shared by all three pillars of sustainability (Figure 4). These criteria were *dependence on other productive sectors*, *ecosystem services*, and *biodiversity* (including both animal and plant biodiversity).

Table 1. Indicators of sustainability divided into criteria, principles, and pillars of sustainability.

Pillar	Principle	Criteria	Indicator	References
Environmental	Best management practices	Feed efficiency	Nitrogen efficiency	[27–29]
			Feed intake	[27,30–36]
			Energy utilization	[30,35]
		Dependence on other productive sectors	Feed management	[37]
			Feed composition	[27,30,36,38–54]
			Feed self-sufficiency	[18,43,55–60]
		Herd management	Animal health and welfare	[3,37,55,56,61–78]
		Resource use	Energy self-sufficiency	[12,18,27,37–39,43,46,47,49,55,56,64,71,79–130]
			Water management	[18,37,55,77,80,82,104,105,119,120,124–126,129,131–135]
			Waste management use	[37,85]
	Environmental quality	Water quality	Eutrophication potential	[80,82,83,111,136–140]
			Acidification potential	[82,83,92,111,137,138]
			Water footprint	[132,134,141]
		Contribution to climate change	Global warming potential	[12,18,27,29,31,33,35,38–40,43,45–48,50,51,53–55,59,64,66,67,70,71,74,79–82,84–87,89,92,94,97–99,101,104,105,107–111,114–118,121–126,129,130,136,138,140–220]
		Air quality	Eutrophication potential	[46,82,86,124,138,148,149,190,207,209,217,221]
			Acidification potential	[32,80–82,86,87,124,138,148,149,190,205,207,217,221]
		Soil quality	Nutrient use efficiency	[12,38,127,222]
			Soil organic carbon	[33,71,88,92,106,144,149,177,202,223–226]
			Soil erosion	[18,71]
			Eutrophication potential	[43,81,82,84,92,106–108,111,114,140,187,221,227]
			Acidification potential	[43,47,81,82,92,106,107,111,114,136,173,187,221]
			Land management practices	[18,30,31,33,38,39,43,46,47,49–51,55,61,68,80–82,84–86,88,91–93,96,99,105–108,124,126,136,139,143,146,148,155,158,168,173,175,186,187,191,202,207,211,216,225,227–233]
	Biodiversity	Animal biodiversity	Species richness	[124,156,211,225,229,234]
			Soil fauna	[234]
			Presence of endangered species	[156]
		Plant biodiversity	Species richness	[124,156,211,225,229,234,235]
			Floral intensity	[93]
			Dominant plant species	[113]
			Presence of endangered species	[156]
		Ecosystem services	Habitat sustainability	[82,156,157,236]
			Participation in agri-environmental scheme	[237]
			Grassland management	[43,235]
			Preserving ecological area	[56,103,159,234]
			Biodiversity conservation	[157,235,238]

Table 1. *Cont.*

Pillar	Principle	Criteria	Indicator	References
Economic	Profitability	Farm income	Total costs	[12,14,18,52,55,59,61,87,91,124,143,150,151,166,212,239–244]
			Farm economic size	[245]
			Farm income diversification	[245]
		Profit	Profit per workforce and unit of land	[14,86,150,153,154,163,246]
		Economic return	Farm gross margin	[14,63,85,109,151,154,241]
		Dairy product sales	Product value	[18,185,210,241,247]
			Product price	[59,240,242]
			Value added	[41,85,91,152,235,245–247]
			Product quality	[128,141,242,248]
	Resilience	Dependence on other productive sectors	Feed self-sufficiency	[18,43,55–60]
			Economic self-sufficiency	[18]
			Energy self-sufficiency	[12,18,27,37–39,43,46,47,49,55,56,64,71,79–130]
			CAP independency	[55,57,58,157,169,228,233,237,238,246,247,249]
			Market orientation	[86,153,154,250]
		Farmer attitude	Farmer age	[12,86,245,246]
			Farmer gender	[12,245,246]
			Farmer goal	[155,251]
		Business resilience	Economic viability	[59,153,154,199]
			Innovation	[56,64,86,154,252]
			Farm cooperation	[88]
			Investment capacity	[30,86]
		Agricultural system diversity	Farm business diversification	[18,66,245,247,253]
			CAP payments	[64]
			Participation in agri-environmental scheme	[237]
	Efficiency	Productivity	Dairy production	[52,55,141,216,236,242,244,254,255]
			Animal health and welfare	[3,37,55,56,61–78]
			Total costs	[55,59,150,166,239,243,244]
			Eco-efficiency	[41]
	Environmental pressure	Biodiversity	Herbage nutritive value	[93,225]
			Biodiversity conservation	[235,238]
		Ecosystem services	Pasture maintenance	[21,27,32,33,51,55,59,70,71,76,82,92,93,98,113,119,120,141,144,146,148,163,171,177,187–192,199,223,228,236,238,244,256–262]
			Preserving ecological area	[56,103,159,234]
Social	Farmer sustainability	Quality of life	Work–life balance	[12,18,55,59,86,87,153,263]
			Labour input	[151]
			Labour efficiency	[18]
			Labour conditions	[61,263]
		Farmer attitude	Innovation	[56,64,86,154,252]
			Awareness	[264]
			Motivation	[3,18,41,42,44,62,63,69,72,75,251,264–266]
			Farm cooperation	[88]
			Animal health and welfare	[3,37,55,56,61–78]

Table 1. *Cont.*

Pillar	Principle	Criteria	Indicator	References
Social	Social sustainability	Sustainability of farm life	Farmer age	[12,86,245,246]
			Farmer gender	[12,245,246]
			Farmer education	[12,153,267]
			Equal opportunities	[61,263,268]
			Salaries	[131,237,268]
			Access to health services and medical care	[131,200,263]
		Social learning	Community engagement	[61,151,263,265,269–271]
			Social responsibility	[61,271]
		Food quality	Food safety	[68,268]
			Food security	[66,268]
			Product quality	[128,141,242,248]
		Ecosystem services	Preserving ecological area	[56,103,159,234]
			Aesthetic landscapes	[18,66,236,247]
			Pasture maintenance	[21,27,32,33,51,55,59,70,71,76,82,92, 93,98,113,119,120,141,144,146,148, 163,171,177,187–192,199,223,228,236,238,244,256–262]
		Biodiversity	Preserving ecological area	[56,103,159,234]
			Aesthetic landscapes	[18,66,236,247]
			Biodiversity conservation	[238]
	Economic sustainability	Dependence on other productive sectors	CAP independency	[55,57,58,157,169,228,233,237,238, 246,247,249]
			Feed self-sufficiency	[18,43,55–60]
			Energy self-sufficiency	[12,18,27,37–39,43,46,47,49,55,56,64,71,79–130]
		Eco-efficiency	Eco-efficiency	[41]
		Economic security and farm succession	Economic security and farm succession	[151,268]

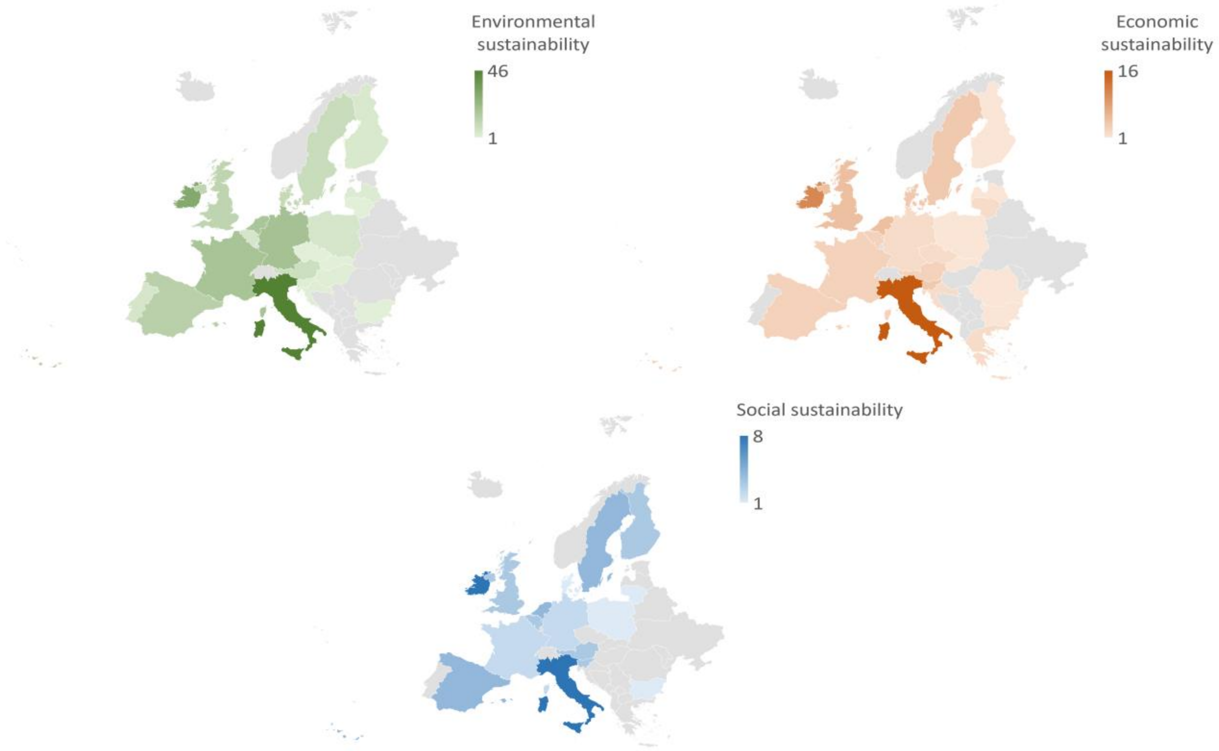

Figure 3. Number of records realized per country considering the three dimensions of sustainability.

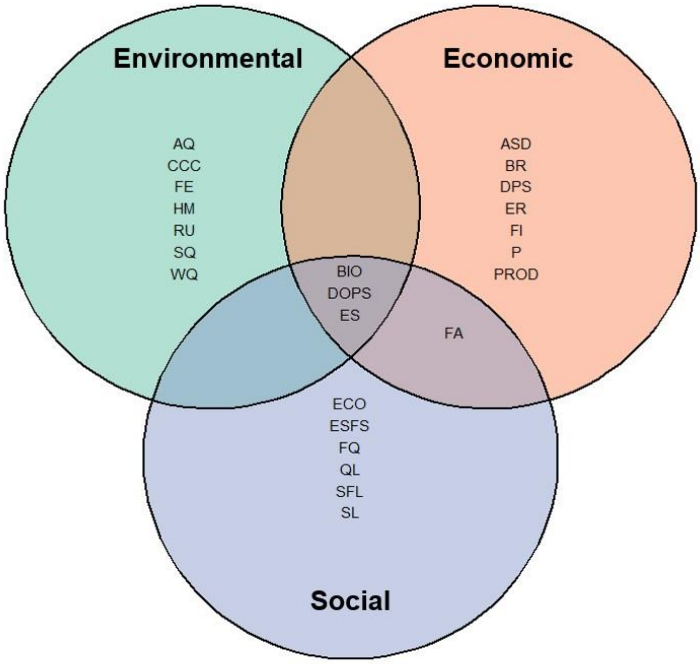

Figure 4. Criteria divided into three pillars of sustainability. Abbreviations: AQ = air quality; ASD = agricultural system diversity; BIO = biodiversity; BR = business resilience; CCC = contribution to climate change; DOPS = dependence on other productive sectors; DPS = dairy product sales; ECO = eco-efficiency; ER = economic return; ES = ecosystem services; ESFS = economic security and farm succession; FA = farmer attitude; FE = feed efficiency; FI = farm income; FQ = food quality; HM = herd management; P = profit; PROD = productivity; QL = quality of life; RU = resource use; SFL = sustainability of farm life; SL = social learning; SQ = soil quality; WQ = water quality.

Sustainability Indicators

The 70 indicators found through the literature search were divided into the various dimensions of sustainability. In particular, 31.4% of the indicators were associated with the environmental pillar, 25.7% with the economic pillar, and 24.3% with the social pillar (Figure 5). In addition, some criteria were shared between/among pillars: 1.4% between the economic and environmental pillars, 10% between the economic and social pillars, and 5% among all the pillars (Figure 5). Among the 22 indicators exclusively associated with environmental sustainability, some were more studied than others: the global warming potential (GWP), the acidification potential, water management, and land management practices.

The findings obtained from our study revealed that 18 indicators described economic sustainability aspects. Among these, the seven most common indicators in the reviewed literature were as follows: the total costs, the value and price of the product, the added value, farm business diversification, the market orientation, farmer goals, and economic viability.

Social sustainability was represented by 17 indicators that identified how dairy farms have both a positive and negative impact on farmers and society [18]. Considering that all the indicators were closely linked to each other, those that best represented the principles of the social pillar of sustainability were as follows: *work–life balance*, *motivation*, *community engagement*, and *aesthetic landscapes*.

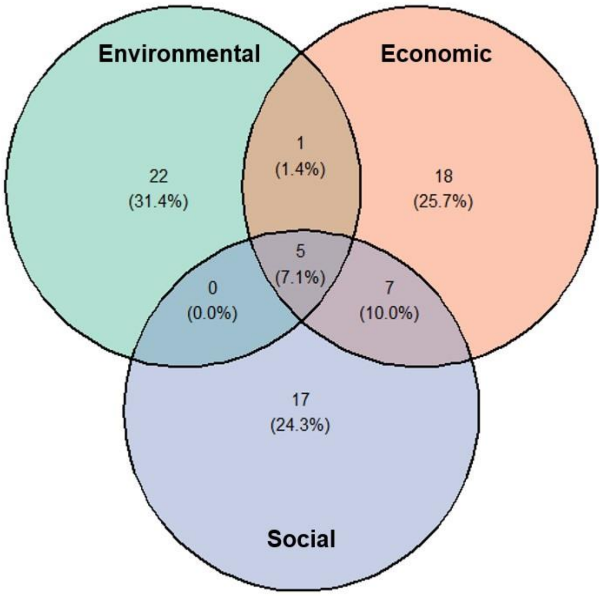

Figure 5. Number of indicators of the three pillars of sustainability according to the selected literature.

4. Discussion

An analysis of the scientific literature revealed a plethora of indicators, with each receiving varying degrees of attention across the reviewed studies (Table 1). The extensive bibliography dedicated to sustainability revealed the keen interest in this field. However, few scientific works provided detailed information about the aggregation method or the weighting assigned to the sustainability pillar indicators (e.g., [247]). Equally, defining threshold values for these indicators proved unattainable. These two aspects highlight the main limits of this study, which should be considered in future research to provide detailed insights. Attention should also be paid to the way in which the indicators are linked each other. In fact, this relationship could be a limiting factor for the compensation of sustainability indicators [272].

4.1. Environmental Indicators

The ***global warming potential*** (***GWP***) is an important indicator that allows for an estimation of which greenhouse gas (GHG) emissions are related to the dairy production system, thus contributing to an assessment of the impact in terms of climate change [142–144]. The most widely used method for estimating the environmental impact is the life cycle assessment (LCA). This method relies on the equations published by the IPCC (Intergovernmental Panel on Climate Change), which allows the CO_2-equivalent emissions for the different greenhouse gases, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), to be estimated The unit used as a reference in most studies (e.g., [145,146,228,239]) was the amount of milk, corrected for the fat and protein content (FPCM).

Ammonia (NH_3) is often discussed in contemporary research, as seen in various studies (e.g., [79,147,228]). While ammonia is not a greenhouse gas, it plays a crucial role in evaluating air quality [147,228]. Specifically, it is associated with the ***acidification potential***, an indicator that measures the potential of substances to contribute to environmental acidification [80,148]. This potential can be assessed using the life cycle assessment (LCA) method and depends on factors such as the organic matter content and the levels of phosphorus and nitrogen. Additionally, some researchers (e.g., [145,147,228]) have examined air acidification by considering other pollutants, such as nitrous oxide (N_2O) and nitrogen oxides (NOx). The acidification potential is a multifaceted indicator, and is crucial for assessing both the air and soil quality [81,82,221]. Another important indicator is ***water management***, which is used to estimate the environmental costs of managing and using water resources [131]. Beyond water management, and linked to it, there are other indicators that can be used to estimate the environmental costs of using water. Among these, the eutrophication potential (also calculated with the LCA method) aims to assess the impact on water due to an excess of nitrogen and phosphorus from activities such as livestock farming (e.g., [80,83,136]). However, despite the research on water management by several authors (e.g., [37,131,132]), the water quality and water footprint are still poorly treated topics, thus highlighting the need for further research to provide detailed insights.

As far as the soil quality is concerned, ***land management practices*** was the second most cited indicator in the literature (e.g., [18,38,84]). Specifically, it associates various soil management techniques (e.g., different cultivation practices) with an environmental impact using the LCA method (e.g., [61,143]).

Lastly, the ***composition of the diet*** was another widely studied topic because it is linked to several other indicators (e.g., [39,40]). In fact, it is useful for partially explaining and measuring other indicators, such as the global warming potential [147,239], whose measure is influenced by the percentage of fiber in the diet of cattle, which affects the amount of greenhouse gases (especially methane) produced by the animals [79].

4.2. Economic Indicators

The ***total costs*** indicator was one of the most widely used indicators for describing the economic sustainability [55,239]. This, in conjunction with the "farm economic size" and "farm income diversification", constituted part of the "farm income" criterion. The latter results from the sum of the farm's fixed costs, the variable costs related to animal and crop production, and the costs for external services (i.e., veterinary care expenses) [18]. Along with the production, the total cost of a farm is a good indicator that provides information about the farm's production efficiency (low costs and a high production are indicators of a high production efficiency) (e.g., [150,151,240]).

The ***value and price*** of the product are indicators that lay the foundation for calculating a farm's economic productivity. They represent the economic value (in EUR) of the goods and services produced by a farm [247]. Along with the concept of the product value, the added value of a product describes the farm's financial benefit [85,245,246]. Essentially, the added value refers to the increase in the value generated by a production process, calculated from the average value of the product prior to taxes [152,247]. An example of added value applied to the milk production system is the milk composition (proteins, fats, and somatic cell count) or the method of production, measured in EUR per unit of milk processed [85,246,247].

The ***farm business diversification*** indicator represents a farm's capacity to generate various externalities through both its agricultural and non-agricultural activities [18,247]. This indicator is an integral part of the multifunctionality concept. The greater the range of goods and services a company provides beyond its primary production, the more it is considered to be multifunctional. The market orientation of dairy farms identifies the percentage of the farm income derived from production, without considering the income obtained from agricultural subsidies [153,250]. High percentage values of this indicator are associated with a low dependence on payments or agricultural subsidies and, in turn, on other productive sectors [154]. This indicator is closely related to "farm business diversification", as it allows the farm income to be implemented, hence reducing the need for agricultural subsidies.

The ***farmer goal*** is the indicator that quantifies a farmer's attitude towards business strategies or goals, in turn allowing their financial income to be increased [251]. This indicator, which is analogous to farm business diversification and market orientation, is also linked to economic resilience, i.e., the ability to adapt and prevent the risk of income losses [155].

The ***economic viability*** of a farm is defined as the farm's capacity to fully remunerate its family labor based on the average agricultural wage [154]. This indicator, although poorly treated in the current literature, is very interesting because it describes the farm's business resilience.

4.3. Social Indicators

The ***work–life balance*** indicator represents the average number of hours of work per week carried out by a farmer [86]. Along with wages, it is considered one of the fundamental aspects of social sustainability [18,87]. The lower the value of the work–life balance, the more positive its social impact [153].

The ***motivation***, also known as "farmer attitude", is an indicator that describes the perceptions and approaches of a farmer regarding various aspects, i.e., animal welfare [3,62,63], environmental sustainability [41], sustainable farming practices [264], and taking risks [42]. Although the studies on this indicator are empirical, it has been shown that the farmer's attitude (influenced by age, sex, and education) can significantly affect the socio-economic efficiency of the farm [41].

Community engagement is another important indicator that needs to be considered in the field of social sustainability. Despite having been poorly treated in the literature, this indicator is notably important, since it is used to describe the perception of society (represented by residents and tourists) regarding ecosystem services, animal husbandry systems, animal welfare, and different agricultural practices [263]. In fact, the level of societal acceptance not only drives the scientific and farmers' interests towards certain issues, but also greatly influences the farmers' attitude, motivation, and job satisfaction. Another factor that usually positively influences the opinion of the community is the presence of aesthetic landscapes. This indicator, which is relevant in terms of both ecosystem services and biodiversity preservation, reflects the dedication of farms to activities aimed at preserving landscapes, thereby supporting both plant and animal communities [18,236,247].

4.4. Sustainability Indicators

4.4.1. Two-Pillar Indicators

The indicators that are associated with two pillars of sustainability are *participation in agri-environmental schemes, innovation, age of farmers, independence from subsidies of common agricultural policies, and farm cooperation*.

Participation in agri-environmental schemes is an indicator of environmental and economic sustainability. It combines the need to increase the environmental sustainability of agricultural activities with the possibility of developing the farm's economy. In fact, the so-called "more sustainable" activities also exert a negative impact on the farm's economy. For this reason, subsidies may be granted to farms that engage in these activities [237].

The ***innovation*** indicator is becoming increasingly important from both an economic and a social sustainability point of view. A farm must achieve a high level of innovation to observe tangible effects on its business economy [252]. Nevertheless, several studies [56,64,154] have reported that the innovation of farms provides long-term information about a farm's sustainability and resilience [86]. As a two-dimensional indicator, it also exerts effects on the social dimension and, particularly, on farmers. In fact, innovation can facilitate barn work (e.g., milking robots, automatic feeders, etc.), also influencing other indicators of the social dimension of sustainability in turn, such as the "work–life balance" and "farmers' motivation".

The ***age of farmers*** indicator is used to ascertain a business's sustainability, and is closely related to the economic performance of the farm [86]. In fact, some authors [12,246] have reported that companies with a younger age profile tend to exhibit a higher level of innovation, increased business cooperation, and a greater investment capacity, which are all indicators related to corporate economic security [245]. In the social dimension of sustainability, the age of farmers is intricately tied to their motivation to adopt practices geared towards sustainability and enhance community engagement [265].

Independence from subsidies of common agricultural policies (CAP) is a very important indicator, linked to both the economic and social dimensions of sustainability. This indicator provides an overview of the farm's economic stability. Indeed, CAP subsidies can have a positive impact by supporting the economy. However, they can also be perceived negatively in certain contexts [246]. The criterion that describes this indicator is the dependence on other production sectors, which includes both the economic and social dimensions of sustainability. The farm's reliance on CAP subsidies is often inversely correlated with its economic stability. This means that a higher level of subsidy dependency tends to correspond to a lower economic stability [57]. Consequently, in these cases, the farmer's motivation and attitude will likely be lower [237].

The ***farm cooperation***, which is measured through an LCA method, allows both the environmental and economic performances to be increased [88], and is linked to the eco-efficiency indicator, defined as "the efficiency with which the ecological resources are used to fulfill human needs" [41]. A direct proportional relationship exists between the environmental performance and business cooperation. In fact, increasing the cooperation tends to reduce the environmental impacts of a farm, thereby enhancing its environmental performance. Similarly, heightened cooperation leads to decreased company costs, specifically those associated with production activities, resulting in an improved economic performance [88].

4.4.2. Three-Pillar Indicators

The indicators that are associated with all three pillars of sustainability are "*feed self-sufficiency*", "*animal health and welfare*", "*energy self-sufficiency*", and "*biodiversity conservation*".

Feed self-sufficiency refers to a farm's ability to be independent from the purchase of animal feed, by promoting corporate economic circularity [89]. From an environmental point of view, the use of homegrown feedstuffs allows the purchase of food products to be reduced and, consequently, the economic autonomy of the farm to be increased [58]. Conversely, employing homegrown feedstuffs helps reduce a farm's nitrogen balance and minimize the environmental impacts associated with transporting off-farm feedstuffs [59]. Moreover, companies show a high interest towards farms that feed their livestock with local food, rather than food imported from foreign countries [18].

The indicator ***animal health and welfare*** can be assessed using the Welfare Quality Assessment Protocol® method, which incorporates 33 measures collected from each farm, grouped into 12 criteria that are, in turn, divided into four principles: good feeding, good housing, good health, and appropriate behavior. However, due to the difficulties in the application of this protocol, a simplified new version called the welfare monitor [62] has started to be used. This new protocol allows the above four principles to be analyzed using 13 measures. In this way, it is possible to properly assess an animal's health in a short time. In spite of these considerations, the animal health and welfare indicator is not always associated with corporate sustainability, despite falling under all three pillars of sustainability [26]. Environmentally, maintaining good animal health enhances the production efficiency and reduces the need for medications, resulting in a decreased environmental impact and a more sustainable business economy [37,65,156]. Animal health and welfare is usually associated with the social dimension. In fact, this indicator is the one that mostly influences the societal acceptance of agricultural and livestock farming practices [61,62,65].

The ***energy self-sufficiency*** indicator, which is expressed as a percentage, is calculated as the ratio between the energy produced by a farm and the overall energy consumed [18,90]. From an environmental perspective, this indicator is used to assess how the use of resources exerts an impact on the environment. The LCA is the method most widely used to assess the magnitude of the environmental impact and involves measuring the differences in terms of CO_2 emissions, comparing renewable and non-renewable energies [91]. The use of renewable energies, beyond having a lower environmental impact, increases the level of acceptance of societies towards farming practices. This indicator is also strictly linked to the economic dimension. In fact, the independence from purchasing energy leads to lower costs and encourages the better utilization or reuse of farm resources, thereby promoting a circular economy within the farm [12,18].

The ***biodiversity conservation*** indicator describes two different classification criteria: ecosystem services and biodiversity. This indicator has implications for all the dimensions of sustainability. In fact, from an environmental perspective, it allows for a measurement of the attention given by farmers towards maintaining natural habitats and, consequently, a high level of biodiversity [157]. As far as the economic aspects are concerned, maintaining biodiversity (in conjunction with other issues) is recognized as a "provisioning" ecosystem service for farmers. Stakeholders, who represent members of society, acknowledge the "ecosystem service" attribute linked to this indicator. They perceive the preservation of biodiversity as pivotal in maintaining traditional cultural landscapes [238].

5. Conclusions

Given the growing relevance of sustainability reporting by agri-food sector companies, many organizations have developed sets of indicators that can be used for the definition, assessment, and reporting of sustainability. For instance, the Food and Agriculture Organization (FAO) and the Global Reporting Initiative (GRI) have developed indicators that are useful for calculating the sustainability of the agriculture, aquaculture, and fishing sectors at the level of the European Union. Despite belonging to the agricultural sector, not all indicators are suitable for describing the reality of dairy farms.

Our study identified 70 sustainability indicators divided into three pillars of sustainability (i.e., environmental, economic, and social). From the analysis, it is clear that some indicators are not only shared between two or more dimensions of sustainability (e.g., animal welfare, energy self-sufficiency, food self-sufficiency, and biodiversity conservation), but they are also closely linked to each other (e.g., farmers' ages and innovation, farmers' goals and motivation, GWP, and land management practices). This calls into question the possible compensation among indicators in a sustainability assessment.

Although a large number of indicators were identified in this research, it was not possible to identify univocal and shared measures to calculate them.

The adoption of indicators can enhance the completeness of understanding and the awareness of sustainability issues among all stakeholders, starting with the farmer. An increased awareness among farmers would allow for the identification of critical points and actions aimed at improving farm management levels. In this way, farms can not only enhance their efficiency but also improve the public opinion of dairy cattle farms, thereby gaining greater support from society. Furthermore, the identification and quantification of sustainability in agricultural farms could lead to rewards in terms of public funding. Indeed, one of the primary challenges of community policies is to clearly and distinctly identify the farming systems/farms that are most capable of achieving community objectives concerning the agroecological transition. Within this context, a fourth pillar of sustainability, governance, could also be considered. This pillar already began to be recognized in the 2000s, and it includes rules for creating sustainability reports for agricultural farms that consider the effects of political–institutional decisions in general. However, future studies are certainly needed to develop a clear definition of the concrete goals that must be achieved for dairy cattle farms to be considered sustainable.

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References

1. European Commission. Directorate General for Agriculture and Rural Development. In *EU Agricultural Outlook for Markets, Income and Environment 2022–2032*; European Commission, 2022. Available online: https://agriculture.ec.europa.eu/system/files/2023-04/agricultural-outlook-2022-report_en_0.pdf (accessed on 9 May 2024).
2. Autio, M.; Sekki, S.; Autio, J.; Peltonen, K.; Niva, M. Towards De-Dairyfication of the Diet?—Consumers Downshifting Milk, yet Justifying Their Dairy Pleasures. *Front. Sustain.* **2023**, *4*, 975679. [CrossRef]
3. Heise, H.; Theuvsen, L. German Dairy Farmers' Attitudes toward Farm Animal Welfare and Their Willingness to Participate in Animal Welfare Programs: A Cluster Analysis. *Int. Food Agribus. Manag. Rev.* **2018**, *21*, 1121–1136. [CrossRef]
4. Staffolani, G.; Bentivoglio, D.; Finco, A. Consumers' Purchasing Determinants towards Mountain Food Products. *Sustainability* **2022**, *14*, 8282. [CrossRef]
5. Duglio, S.; Salotti, G.; Mascadri, G. Conditions for Operating in Marginal Mountain Areas: The Local Farmer's Perspective. *Societies* **2023**, *13*, 107. [CrossRef]
6. Pawlewicz, A.; Pawlewicz, K. The Risk of Agricultural Land Abandonment as a Socioeconomic Challenge for the Development of Agriculture in the European Union. *Sustainability* **2023**, *15*, 3233. [CrossRef]
7. Fayet, C.M.J.; Reilly, K.H.; Van Ham, C.; Verburg, P.H. What Is the Future of Abandoned Agricultural Lands? A Systematic Review of Alternative Trajectories in Europe. *Land Use Policy* **2022**, *112*, 105833. [CrossRef]
8. Battaglini, L.; Bovolenta, S.; Gusmeroli, F.; Salvador, S.; Sturaro, E. Environmental Sustainability of Alpine Livestock Farms. *Ital. J. Anim. Sci.* **2014**, *13*, 431–443. [CrossRef]
9. Latruffe, L.; Niedermayr, A.; Desjeux, Y.; Dakpo, K.H.; Ayouba, K.; Schaller, L.; Kantelhardt, J.; Jin, Y.; Kilcline, K.; Ryan, M.; et al. Identifying and Assessing Intensive and Extensive Technologies in European Dairy Farming. *Eur. Rev. Agric. Econ.* **2023**, *50*, 1482–1519. [CrossRef]
10. Clay, N.; Garnett, T.; Lorimer, J. Dairy Intensification: Drivers, Impacts and Alternatives. *Ambio* **2020**, *95*, 35–48. [CrossRef]
11. European Commission. A Long-Term Vision for the EU's Rural Areas—Towards Stronger, Connected, Resilient and Prosperous Rural Areas by 2040. Available online: https://www.fao.org/family-farming/detail/en/c/1414177/ (accessed on 28 March 2024).
12. Masi, M.; Vecchio, Y.; Pauselli, G.; Di Pasquale, J.; Adinolfi, F. A Typological Classification for Assessing Farm Sustainability in the Italian Bovine Dairy Sector. *Sustainability* **2021**, *13*, 7097. [CrossRef]
13. Cardillo, C.; Cimino, O.; De Rosa, M.; Francescone, M. The Evolution of Multifunctional Agriculture in Italy. *Sustainability* **2023**, *15*, 11403. [CrossRef]
14. Koutouzidou, G.; Ragkos, A.; Melfou, K. Evolution of the Structure and Economic Management of the Dairy Cow Sector. *Sustainability* **2022**, *14*, 11602. [CrossRef]
15. McGarr-O'Brien, K.; Herron, J.; Shalloo, L.; De Boer, I.J.M.; De Olde, E.M. Characterising Sustainability Certification Standards in Dairy Production. *Animal* **2023**, *17*, 100863. [CrossRef]
16. Nguyen, T.T.T.; Richardson, C.M.; Post, M.; Amer, P.R.; Nieuwhof, G.J.; Thurn, P.; Shaffer, M. The Sustainability Index: A New Tool to Breed for Reduced Greenhouse-Gas Emissions Intensity in Australian Dairy Cattle. *Anim. Prod. Sci.* **2023**, *63*, 1126–1135. [CrossRef]
17. Hassani, L.; Kakhki, M.D.; Sabouni, M.S.; Fantke, P. Quantitative Sustainability Assessment Applied to Dairy Farms. In *Perspectives on Development in the Middle East and North Africa (MENA) Region*; Springer: Singapore, 2020; pp. 11–20. [CrossRef]
18. De Otálora, X.D.; Del Prado, A.; Dragoni, F.; Estellés, F.; Amon, B. Evaluating Three-Pillar Sustainability Modelling Approaches for Dairy Cattle Production Systems. *Sustainability* **2021**, *13*, 6332. [CrossRef]
19. Rios, G.P.; Botero, S. An Integrated Indicator to Analyze Sustainability in Specialized Dairy Farms in Antioquia—Colombia. *Sustainability* **2020**, *12*, 9595. [CrossRef]
20. Zira, S.; Röös, E.; Rydhmer, L.; Hoffmann, R. Sustainability Assessment of Economic, Environmental and Social Impacts, Feed-Food Competition and Economic Robustness of Dairy and Beef Farming Systems in South Western Europe. *Sustain. Prod. Consum.* **2023**, *36*, 439–448. [CrossRef]
21. Brennan, M.; Hennessy, T.; Dillon, E. Embedding Animal Welfare in Sustainability Assessment: An Indicator Approach. *Ir. J. Agric. Food Res.* **2021**, *60*, 129–141. [CrossRef]
22. SAFA (Sustainability Assessment of Food and Agriculture Systems). Tool: User Manual Version 2.2.40. Available online: https://openknowledge.fao.org/handle/20.500.14283/i3957e (accessed on 9 May 2024).
23. Strozzilaan, B.; Amsterdam, H. *GRI Sector Standard Project Agriculture*; Aquaculture and Fishing; GRI: Amsterdam, The Netherlands, 2022; ISBN 978-90-8866-138-9.
24. Baillet, V.; Balaine, L.; Díaz De Otálora, X.; Rodriguez, D.G.P.; Frątczak-Müller, J.; Flø, B.E.; Amon, B.; Alem, H.; Anestis, V.; Bartzanas, T.; et al. *Dexi-Dairy Indicator Handbook—Sustainability Tree and Selected Indicators for Assessing European Specialised Dairy Farms*; 2022. [CrossRef]

25. Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews. *J. Clin. Epidemiol.* **2021**, *134*, 178–189. [CrossRef]
26. Arvidsson Segerkvist, K.; Hansson, H.; Sonesson, U.; Gunnarsson, S. Research on Environmental, Economic, and Social Sustainability in Dairy Farming: A Systematic Mapping of Current Literature. *Sustainability* **2020**, *12*, 5502. [CrossRef]
27. Dieterich, B.; Finnan, J.; Hochstrasser, T.; Müller, C. The Greenhouse Gas Balance of a Dairy Farm as Influenced by the Uptake of Biogas Production. *Bioenergy Res.* **2014**, *7*, 95–109. [CrossRef]
28. Karandušovská, I.; Mihina, Š.; Bošanský, M. Impact of Construction and Technological Solution of Dairy Cows Housing on Production of Ammonia and Greenhouse Gases in Winter. *Res. Agric. Eng.* **2015**, *61*, S13–S20. [CrossRef]
29. Martin, G.; Willaume, M. A Diachronic Study of Greenhouse Gas Emissions of French Dairy Farms According to Adaptation Pathways. *Agric. Ecosyst. Environ.* **2016**, *221*, 50–59. [CrossRef]
30. Bonazzi, G.; Iotti, M. Interest Coverage Ratios (ICRs) and Financial Sustainability: Application to Firms with Bovine Dairy Livestock. *Am. J. Agric. Biol. Sci.* **2014**, *9*, 482–489. [CrossRef]
31. Meul, M.; Van Middelaar, C.E.; de Boer, I.J.M.; Van Passel, S.; Fremaut, D.; Haesaert, G. Potential of Life Cycle Assessment to Support Environmental Decision Making at Commercial Dairy Farms. *Agric. Syst.* **2014**, *131*, 105–115. [CrossRef]
32. Mihailescu, E.; Ryan, W.; Murphy, P.N.C.; Casey, I.A.; Humphreys, J. Economic Impacts of Nitrogen and Phosphorus Use Efficiency on Nineteen Intensive Grass-Based Dairy Farms in the South of Ireland. *Agric. Syst.* **2015**, *132*, 121–132. [CrossRef]
33. Sabia, E.; Kühl, S.; Flach, L.; Lambertz, C.; Gauly, M. Effect of Feed Concentrate Intake on the Environmental Impact of Dairy Cows in an Alpine Mountain Region Including Soil Carbon Sequestration and Effect on Biodiversity. *Sustainability* **2020**, *12*, 2128. [CrossRef]
34. Egger-Danner, C.; Köck, A.; Fuchs, K.; Grassauer, B.; Fuerst-Waltl, B.; Obritzhauser, W. Use of Benchmarking to Monitor and Analyze Effects of Herd Size and Herd Milk Yield on Cattle Health and Welfare in Austrian Dairy Farms. *J. Dairy Sci.* **2020**, *103*, 7598–7610. [CrossRef] [PubMed]
35. Ramin, M.; Fant, P.; Huhtanen, P. The Effects of Gradual Replacement of Barley with Oats on Enteric Methane Emissions, Rumen Fermentation, Milk Production, and Energy Utilization in Dairy Cows. *J. Dairy Sci.* **2021**, *104*, 5617–5630. [CrossRef]
36. García-Souto, V.; Foray, S.; Lorenzana, R.; Veiga-López, M.; Pereira-Crespo, S.; González-González, L.; Flores-Calvete, G.; Báez, D.; Botana, A.; Resch-Zafra, C. Assessment of Greenhouse Gas Emissions in Dairy Cows Fed with Five Forage Systems. *Ital. J. Anim. Sci.* **2022**, *21*, 378–389. [CrossRef]
37. Zanni, S.; Roccaro, M.; Bocedi, F.; Peli, A.; Bonoli, A. LCA to Estimate the Environmental Impact of Dairy Farms: A Case Study. *Sustainability* **2022**, *14*, 6028. [CrossRef]
38. Oenema, J.; Oenema, O. Intensification of Grassland-Based Dairy Production and Its Impacts on Land, Nitrogen and Phosphorus Use Efficiencies. *Front. Agric. Sci. Eng.* **2021**, *8*, 130–147. [CrossRef]
39. Linderholm, K.; Katterer, T.; Mattsson, J.E. Valuing Carbon Capture in Agricultural Production: Examples from Sweden. *SN Appl. Sci.* **2020**, *2*, 1264. [CrossRef]
40. Bannink, A.; Zom, R.L.G.; Groenestein, K.C.; Dijkstra, J.; Sebek, L.B.J. Applying a Mechanistic Fermentation and Digestion Model for Dairy Cows with Emission and Nutrient Cycling Inventory and Accounting Methodology. *Animal* **2020**, *14*, s406–s416. [CrossRef] [PubMed]
41. Pérez Urdiales, M.; Lansink, A.O.; Wall, A. Eco-Efficiency Among Dairy Farmers: The Importance of Socio-Economic Characteristics and Farmer Attitudes. *Environ. Resour. Econ.* **2016**, *64*, 559–574. [CrossRef]
42. Hansson, H.; Lagerkvist, C.J. Decision Making for Animal Health and Welfare: Integrating Risk-Benefit Analysis with Prospect Theory. *Risk Anal.* **2014**, *34*, 1149–1159. [CrossRef]
43. Salvador, S.; Corazzin, M.; Piasentier, E.; Bovolenta, S. Environmental Assessment of Small-Scale Dairy Farms with Multifunctionality in Mountain Areas. *J. Clean. Prod.* **2016**, *124*, 94–102. [CrossRef]
44. Brennan, M.L.; Wright, N.; Wapenaar, W.; Jarratt, S.; Hobson-West, P.; Richens, I.F.; Kaler, J.; Buchanan, H.; Huxley, J.N.; O'Connor, H.M. Exploring Attitudes and Beliefs towards Implementing Cattle Disease Prevention and Control Measures: A Qualitative Study with Dairy Farmers in Great Britain. *Animals* **2016**, *6*, 61. [CrossRef]
45. Chiumenti, A.; Da Borso, F.; Pezzuolo, A.; Sartori, L.; Chiumenti, R. Ammonia and Greenhouse Gas Emissions from Slatted Dairy Barn Floors Cleaned by Robotic Scrapers. *Res. Agric. Eng.* **2018**, *64*, 26–33. [CrossRef]
46. Todde, G.; Murgia, L.; Caria, M.; Pazzona, A. A Comprehensive Energy Analysis and Related Carbon Footprint of Dairy Farms, Part 1: Direct Energy Requirements. *Energies* **2018**, *11*, 451. [CrossRef]
47. Schueler, M.; Paulsen, H.M.; Berg, W.; Prochnow, A. Accounting for Inter-Annual Variability of Farm Activity Data for Calculation of Greenhouse Gas Emissions in Dairy Farming. *Int. J. Life Cycle Assess.* **2018**, *23*, 41–54. [CrossRef]
48. Karlsson, J.; Ramin, M.; Kass, M.; Lindberg, M.; Holtenius, K. Effects of Replacing Wheat Starch with Glycerol on Methane Emissions, Milk Production, and Feed Efficiency in Dairy Cows Fed Grass Silage-Based Diets. *J. Dairy Sci.* **2019**, *102*, 7927–7935. [CrossRef] [PubMed]
49. Frank, H.; Schmid, H.; Hülsbergen, K.-J. Modelling Greenhouse Gas Emissions from Organic and Conventional Dairy Farms. *Landbauforschung* **2019**, *69*, 37–46. [CrossRef]

50. Lovarelli, D.; Bava, L.; Zucali, M.; D'Imporzano, G.; Adani, F.; Tamburini, A.; Sandrucci, A. Improvements to Dairy Farms for Environmental Sustainability in Grana Padano and Parmigiano Reggiano Production Systems. *Ital. J. Anim. Sci.* **2019**, *18*, 1035–1048. [CrossRef]
51. Ibidhi, R.; Calsamiglia, S. Carbon Footprint Assessment of Spanish Dairy Cattle Farms: Effectiveness of Dietary and Farm Management Practices as a Mitigation Strategy. *Animals* **2020**, *10*, 2083. [CrossRef]
52. Kühl, S.; Flach, L.; Gauly, M. Economic Assessment of Small-Scale Mountain Dairy Farms in South Tyrol Depending on Feed Intake and Breed. *Ital. J. Anim. Sci.* **2020**, *19*, 41–50. [CrossRef]
53. Nowakowicz-Debek, B.; Wlazło, L.; Szymula, A.; Ossowski, M.; Kasela, M.; Chmielowiec-Korzeniowska, A.; Bis-Wencel, H. Estimating Methane Emissions from a Dairy Farm Using a Computer Program. *Atmosphere* **2020**, *11*, 803. [CrossRef]
54. Grossi, S.; Compiani, R.; Rossi, L.; Dell'anno, M.; Castillo, I.; Sgoifo Rossi, C.A. Effect of Slow-Release Urea Administration on Production Performance, Health Status, Diet Digestibility, and Environmental Sustainability in Lactating Dairy Cows. *Animals* **2021**, *11*, 2405. [CrossRef] [PubMed]
55. Jaklič, T.; Juvančič, L.; Kavčič, S.; Debeljak, M. Complementarity of Socio-Economic and Emergy Evaluation of Agricultural Production Systems: The Case of Slovenian Dairy Sector. *Ecol. Econ.* **2014**, *107*, 469–481. [CrossRef]
56. Nicholas, P.K.; Mandolesi, S.; Naspetti, S.; Zanoli, R. Innovations in Low Input and Organic Dairy Supply Chains-What Is Acceptable in Europe? *J. Dairy Sci.* **2014**, *97*, 1157–1167. [CrossRef]
57. Duluins, O.; Riera, A.; Schuster, M.; Baret, P.V.; Van den Broeck, G. Economic Implications of a Protein Transition: Evidence from Walloon Beef and Dairy Farms. *Front. Sustain. Food Syst.* **2022**, *6*, 803872. [CrossRef]
58. Gaudino, S.; Reidsma, P.; Kanellopoulos, A.; Sacco, D.; van Ittersum, M.K. Integrated Assessment of the EU's Greening Reform and Feed Self-Sufficiency Scenarios on Dairy Farms in Piemonte, Italy. *Agriculture* **2018**, *8*, 137. [CrossRef]
59. O'brien, B.; Hennessy, D. Scientific Appraisal of the Irish Grass-Based Milk Production System as a Sustainable Source of Premium Quality Milk and Dairy Products. *Ir. J. Agric. Food Res.* **2017**, *56*, 120–129. [CrossRef]
60. Senga Kiessé, T.; Heijungs, R.; Corson, M.S. Modeling Production Efficiency and Greenhouse Gas Objectives as a Function of Forage Production of Dairy Farms Using Copula Models. *Environ. Model. Assess.* **2022**, *27*, 413–424. [CrossRef]
61. Zhu, L.; Lansink, A.O. Dynamic Sustainable Productivity Growth of Dutch Dairy Farming. *PLoS ONE* **2022**, *17*, e0264410. [CrossRef]
62. van Eerdenburg, F.J.C.M.; Di Giacinto, A.M.; Hulsen, J.; Snel, B.; Stegeman, J.A. A New, Practical Animal Welfare Assessment for Dairy Farmers. *Animals* **2021**, *11*, 881. [CrossRef]
63. Hansson, H.; Lagerkvist, C.J.; Azar, G. Use and Non-Use Values as Motivational Construct Dimensions for Farm Animal Welfare: Impacts on the Economic Outcome for the Farm. *Animal* **2018**, *12*, 2147–2155. [CrossRef]
64. Hublin, A.; Schneider, D.R.; Džodan, J. Utilization of Biogas Produced by Anaerobic Digestion of Agro-Industrial Waste: Energy, Economic and Environmental Effects. *Waste Manag. Res.* **2014**, *32*, 626–633. [CrossRef]
65. Owusu-Sekyere, E.; Hansson, H.; Telezhenko, E. Use and Non-Use Values to Explain Farmers' Motivation for the Provision of Animal Welfare. *Eur. Rev. Agric. Econ.* **2022**, *49*, 499–525. [CrossRef]
66. Hietala, S.; Smith, L.; Knudsen, M.T.; Kurppa, S.; Padel, S.; Hermansen, J.E. Carbon Footprints of Organic Dairying in Six European Countries—Real Farm Data Analysis. *Org. Agric.* **2015**, *5*, 91–100. [CrossRef]
67. Agostini, A.; Battini, F.; Padella, M.; Giuntoli, J.; Baxter, D.; Marelli, L.; Amaducci, S. Economics of GHG Emissions Mitigation via Biogas Production from Sorghum, Maize and Dairy Farm Manure Digestion in the Po Valley. *Biomass Bioenergy* **2016**, *89*, 58–66. [CrossRef]
68. de Graaf, S.; Vanhonacker, F.; Van Loo, E.J.; Bijttebier, J.; Lauwers, L.; Tuyttens, F.A.M.; Verbeke, W. Market Opportunities for Animal-Friendly Milk in Different Consumer Segments. *Sustainability* **2016**, *8*, 1302. [CrossRef]
69. Van Dijk, L.; Elwes, S.; Main, D.C.J.; Mullan, S.M.; Jamieson, J. Farmer Perspectives on Welfare Outcome Assessment: Learnings from Four Farm Assurance Scheme Consultation Exercises. *Anim. Welf.* **2018**, *27*, 1–11. [CrossRef]
70. Mostert, P.F.; van Middelaar, C.E.; de Boer, I.J.M.; Bokkers, E.A.M. The Impact of Foot Lesions in Dairy Cows on Greenhouse Gas Emissions of Milk Production. *Agric. Syst.* **2018**, *167*, 206–212. [CrossRef]
71. Jaeger, M.; Brügemann, K.; Brandt, H.; König, S. Associations between Precision Sensor Data with Productivity, Health and Welfare Indicator Traits in Native Black and White Dual-Purpose Cattle under Grazing Conditions. *Appl. Anim. Behav. Sci.* **2019**, *212*, 9–18. [CrossRef]
72. Hansson, H.; Lagerkvist, C.J.; Vesala, K.M. Impact of Personal Values and Personality on Motivational Factors for Farmers to Work with Farm Animal Welfare: A Case of Swedish Dairy Farmers. *Anim. Welf.* **2018**, *27*, 133–145. [CrossRef]
73. Krieger, M.; Jones, P.J.; Blanco-Penedo, I.; Duval, J.E.; Emanuelson, U.; Hoischen-Taubner, S.; Sjöström, K.; Sundrum, A. Improving Animal Health on Organic Dairy Farms: Stakeholder Views on Policy Options. *Sustainability* **2020**, *12*, 3001. [CrossRef]
74. Cárdenas, A.; Ammon, C.; Schumacher, B.; Stinner, W.; Herrmann, C.; Schneider, M.; Weinrich, S.; Fischer, P.; Amon, T.; Amon, B. Methane Emissions from the Storage of Liquid Dairy Manure: Influences of Season, Temperature and Storage Duration. *Waste Manag.* **2021**, *121*, 393–402. [CrossRef] [PubMed]
75. Spigarelli, C.; Berton, M.; Corazzin, M.; Gallo, L.; Pinterits, S.; Ramanzin, M.; Ressi, W.; Sturaro, E.; Zuliani, A.; Bovolenta, S. Animal Welfare and Farmers' Satisfaction in Small-Scale Dairy Farms in the Eastern Alps: A "One Welfare" Approach. *Front. Vet. Sci.* **2021**, *8*, 741497. [CrossRef]

76. Crossley, R.E.; Bokkers, E.A.M.; Browne, N.; Sugrue, K.; Kennedy, E.; De Boer, I.J.M.; Conneely, M. Assessing Dairy Cow Welfare during the Grazing and Housing Periods on Spring-Calving, Pasture-Based Dairy Farms. *J. Anim. Sci.* **2021**, *99*, skab093. [CrossRef]
77. Mogensen, L.; Kudahl, A.; Kristensen, T.; Bokkers, E.A.M.; Webb, L.E.; Vaarst, M.; Lehmann, J. Environmental Impact of Dam-Calf Contact in Organic Dairy Systems: A Scenario Study. *Livest. Sci.* **2022**, *258*, 104890. [CrossRef]
78. Almeida, J.G.R.; Lorinquer, E.; Robin, P.; Ribeiro-filho, H.M.N.; Edouard, N. Ammonia and Nitrous Oxide Emissions from Dairy Cows on Straw-Based Litter Systems. *Atmosphere* **2022**, *13*, 283. [CrossRef]
79. van Middelaar, C.E.; Berentsen, P.B.M.; Dijkstra, J.; van Arendonk, J.A.M.; de Boer, I.J.M. Methods to Determine the Relative Value of Genetic Traits in Dairy Cows to Reduce Greenhouse Gas Emissions along the Chain. *J. Dairy Sci.* **2014**, *97*, 5191–5205. [CrossRef] [PubMed]
80. Brizga, J.; Kurppa, S.; Heusala, H. Environmental Impacts of Milking Cows in Latvia. *Sustainability* **2021**, *13*, 784. [CrossRef]
81. Rajaniemi, M.; Jokiniemi, T.; Alakukku, L.; Ahokas, J. Electric Energy Consumption of Milking Process on Some Finnish Dairy Farms. *Agric. Food Sci.* **2017**, *26*, 160–172. [CrossRef]
82. Knudsen, M.T.; Dorca-Preda, T.; Djomo, S.N.; Peña, N.; Padel, S.; Smith, L.G.; Zollitsch, W.; Hörtenhuber, S.; Hermansen, J.E. The Importance of Including Soil Carbon Changes, Ecotoxicity and Biodiversity Impacts in Environmental Life Cycle Assessments of Organic and Conventional Milk in Western Europe. *J. Clean. Prod.* **2019**, *215*, 433–443. [CrossRef]
83. Karolinczak, B.; Dabrowski, W.; Żyłka, R. Evaluation of Dairy Wastewater Treatment Systems Using Carbon Footprint Analysis. *Energies* **2021**, *14*, 5366. [CrossRef]
84. Lindberg, M.; Henriksson, M.; Bååth Jacobsson, S.; Berglund Lundberg, M. Byproduct-Based Concentrates in Swedish Dairy Cow Diets–Evaluation of Environmental Impact and Feed Costs. *Acta Agric. Scand. Anim. Sci.* **2021**, *70*, 132–144. [CrossRef]
85. García-Cornejo, B.; Pérez-Méndez, J.A.; Roibás, D.; Wall, A. Effciency and Sustainability in Farm Diversification Initiatives in Northern Spain. *Sustainability* **2020**, *12*, 3983. [CrossRef]
86. Ryan, M.; Hennessy, T.; Buckley, C.; Dillon, E.J.; Donnellan, T.; Hanrahan, K.; Moran, B. Developing Farm-Level Sustainability Indicators for Ireland Using the Teagasc National Farm Survey. *Ir. J. Agric. Food Res.* **2016**, *55*, 112–125. [CrossRef]
87. López, N.M.; Sáenz, J.L.S.; Biedermann, A.; Tierz, A.S. Sustainability Assessment of Product-Service Systems Using Flows between Systems Approach. *Sustainability* **2020**, *12*, 3415. [CrossRef]
88. Pereira, Á.; Carballo-Penela, A.; González-López, M.; Vence, X. A Case Study of Servicizing in the Farming-Livestock Sector: Organisational Change and Potential Environmental Improvement. *J. Clean. Prod.* **2016**, *124*, 84–93. [CrossRef]
89. Styles, D.; Gibbons, J.; Williams, A.P.; Stichnothe, H.; Chadwick, D.R.; Healey, J.R. Cattle Feed or Bioenergy? Consequential Life Cycle Assessment of Biogas Feedstock Options on Dairy Farms. *GCB Bioenergy* **2015**, *7*, 1034–1049. [CrossRef]
90. Moerkerken, A.; Duijndam, S.; Blasch, J.; van Beukering, P.; Smit, A. Determinants of Energy Efficiency in the Dutch Dairy Sector: Dilemmas for Sustainability. *J. Clean. Prod.* **2021**, *293*, 126095. [CrossRef]
91. Špička, J.; Vintr, T.; Aulová, R.; Machácková, J. Trade-off between the Economic and Environmental Trade-off between the Economic and Environmental. *Agric. Econ. Czech Repub.* **2020**, *66*, 243–250. [CrossRef]
92. O'Brien, D.; Brennan, P.; Humphreys, J.; Ruane, E.; Shalloo, L. An Appraisal of Carbon Footprint of Milk from Commercial Grass-Based Dairy Farms in Ireland According to a Certified Life Cycle Assessment Methodology. *Int. J. Life Cycle Assess.* **2014**, *19*, 1469–1481. [CrossRef]
93. Farruggia, A.; Pomiès, D.; Coppa, M.; Ferlay, A.; Verdier-Metz, I.; Le Morvan, A.; Bethier, A.; Pompanon, F.; Troquier, O.; Martin, B. Animal Performances, Pasture Biodiversity and Dairy Product Quality: How It Works in Contrasted Mountain Grazing Systems. *Agric. Ecosyst. Environ.* **2014**, *185*, 231–244. [CrossRef]
94. Gaudino, S.; Goia, I.; Grignani, C.; Monaco, S.; Sacco, D. Assessing Agro-Environmental Performance of Dairy Farms Innorthwest Italy Based on Aggregated Results from Indicators. *J. Environ. Manag.* **2014**, *140*, 120–134. [CrossRef] [PubMed]
95. Andreasen, S.N.; Sandøe, P.; Forkman, B. Can Animal-Based Welfare Assessment Be Simplified? A Comparison of the Welfare Quality®Protocol for Dairy Cattle and the Simpler and Less Time-Consuming Protocol Developed by the Danish Cattle Federation. *Anim. Welf.* **2014**, *23*, 81–94. [CrossRef]
96. Ross, S.A.; Chagunda, M.G.G.; Topp, C.F.E.; Ennos, R. Effect of Cattle Genotype and Feeding Regime on Greenhouse Gas Emissions Intensity in High Producing Dairy Cows. *Livest. Sci.* **2014**, *170*, 158–171. [CrossRef]
97. Rong, L.; Liu, D.; Pedersen, E.F.; Zhang, G. Effect of Climate Parameters on Air Exchange Rate and Ammonia and Methane Emissions from a Hybrid Ventilated Dairy Cow Building. *Energy Build.* **2014**, *82*, 632–643. [CrossRef]
98. Bos, J.F.F.P.; De Haan, J.; Sukkel, W.; Schils, R.L.M. Energy Use and Greenhouse Gas Emissions in Organic and Conventional Farming Systems in the Netherlands. *NJAS—Wagening. J. Life Sci.* **2014**, *68*, 61–70. [CrossRef]
99. Torquati, B.; Venanzi, S.; Ciani, A.; Diotallevi, F.; Tamburi, V. Environmental Sustainability and Economic Benefits of Dairy Farm Biogas Energy Production: A Case Study in Umbria. *Sustainability* **2014**, *6*, 6696–6713. [CrossRef]
100. Heath, C.; Lin, Y.; Mullan, S.; Browne, W.J.; Main, D. Implementing Welfare Quality®in UK Assurance Schemes: Evaluating the Challenges. *Anim. Welf.* **2014**, *23*, 95–107. [CrossRef]
101. Ghisellini, P.; Protano, G.; Viglia, S.; Gaworski, M.; Setti, M.; Ulgiati, S. Integrated Agricultural and Dairy Production within a Circular Economy Framework. A Comparison of Italian and Polish Farming Systems. *J. Environ. Account. Manag.* **2014**, *2*, 367–384. [CrossRef]

102. Popescu, S.; Borda, C.; Diugan, E.A.; Niculae, M.; Stefan, R.; Sandru, C.D. The Effect of the Housing System on the Welfare Quality of Dairy Cow. *Ital. J. Anim. Sci.* **2014**, *13*, 15–22. [CrossRef]
103. Botreau, R.; Farruggia, A.; Martin, B.; Pomiès, D.; Dumont, B. Towards an Agroecological Assessment of Dairy Systems: Proposal for a Set of Criteria Suited to Mountain Farming. *Animal* **2014**, *8*, 1349–1360. [CrossRef] [PubMed]
104. Petersen, S.O.; Hellwing, A.L.F.; Brask, M.; Højberg, O.; Poulsen, M.; Zhu, Z.; Baral, K.R.; Lund, P. Dietary Nitrate for Methane Mitigation Leads to Nitrous Oxide Emissions from Dairy Cows. *J. Environ. Qual.* **2015**, *44*, 1063–1070. [CrossRef] [PubMed]
105. Pereira, J.; Trindade, H. Impact of the Intensity of Milk Production on Ammonia and Greenhouse Gas Emissions in Portuguese Cattle Farms. *Span. J. Agric. Res.* **2015**, *13*, e06SC05. [CrossRef]
106. Boyland, N.K.; Mlynski, D.T.; James, R.; Brent, L.J.N.; Croft, D.P. The Social Network Structure of a Dynamic Group of Dairy Cows: From Individual to Group Level Patterns. *Appl. Anim. Behav. Sci.* **2016**, *174*, 1–10. [CrossRef]
107. Battini, F.; Agostini, A.; Tabaglio, V.; Amaducci, S. Environmental Impacts of Different Dairy Farming Systems in the Po Valley. *J. Clean. Prod.* **2016**, *112*, 91–102. [CrossRef]
108. Rzeźnik, W.; Mielcarek, P.; Rzeźnik, I. Pilot Study of Greenhouse Gases and Ammonia Emissions from Naturally Ventilated Barns for Dairy Cows. *Pol. J. Environ. Stud.* **2016**, *25*, 2553–2562. [CrossRef] [PubMed]
109. Zucali, M.; Battelli, G.; Battini, M.; Bava, L.; Decimo, M.; Mattiello, S.; Povolo, M.; Brasca, M. Multi-Dimensional Assessment and Scoring System for Dairy Farms. *Ital. J. Anim. Sci.* **2016**, *15*, 492–503. [CrossRef]
110. Wettemann, P.J.C.; Latacz-Lohmann, U. An Efficiency-Based Concept to Assess Potential Cost and Greenhouse Gas Savings on German Dairy Farms. *Agric. Syst.* **2017**, *152*, 27–37. [CrossRef]
111. Auburger, S.; Petig, E.; Bahrs, E. Assessment of Grassland as Biogas Feedstock in Terms of Production Costs and Greenhouse Gas Emissions in Exemplary Federal States of Germany. *Biomass Bioenergy* **2017**, *101*, 44–52. [CrossRef]
112. Todde, G.; Murgia, L.; Caria, M.; Pazzona, A. Dairy Energy Prediction (DEP) Model: A Tool for Predicting Energy Use and Related Emissions and Costs in Dairy Farms. *Comput. Electron. Agric.* **2017**, *135*, 216–221. [CrossRef]
113. Duffková, R.; Hakrová, P.; Brom, J.; Fučík, P.; Novotná, K. Effects of Management Practices in Highland Pastures on Agronomic and Environmental Objectives. *Appl. Ecol. Environ. Res.* **2017**, *15*, 1677–1695. [CrossRef]
114. Salou, T.; Le Mouël, C.; van der Werf, H.M.G. Environmental Impacts of Dairy System Intensification: The Functional Unit Matters! *J. Clean. Prod.* **2017**, *140*, 445–454. [CrossRef]
115. Pierie, F.; Dsouza, A.; van Someren, C.E.J.; Benders, R.M.J.; van Gemert, W.J.T.; Moll, H.C. Improving the Sustainability of Farming Practices through the Use of a Symbiotic Approach for Anaerobic Digestion and Digestate Processing. *Resources* **2017**, *6*, 50. [CrossRef]
116. Vida, E.; Tedesco, D.E.A. The Carbon Footprint of Integrated Milk Production and Renewable Energy Systems—A Case Study. *Sci. Total Environ.* **2017**, *609*, 1286–1294. [CrossRef]
117. Todde, G.; Murgia, L.; Caria, M.; Pazzona, A. A Comprehensive Energy Analysis and Related Carbon Footprint of Dairy Farms, Part 2: Investigation and Modeling of Indirect Energy Requirements. *Energies* **2018**, *11*, 463. [CrossRef]
118. Torrellas, M.; Burgos, L.; Tey, L.; Noguerol, J.; Riau, V.; Palatsi, J.; Antón, A.; Flotats, X.; Bonmatí, A. Different Approaches to Assess the Environmental Performance of a Cow Manure Biogas Plant. *Atmos. Environ.* **2018**, *177*, 203–213. [CrossRef]
119. Shortall, J.; O'Brien, B.; Sleator, R.D.; Upton, J. Daily and Seasonal Trends of Electricity and Water Use on Pasture-Based Automatic Milking Dairy Farms. *J. Dairy Sci.* **2018**, *101*, 1565–1578. [CrossRef] [PubMed]
120. Shine, P.; Scully, T.; Upton, J.; Shalloo, L.; Murphy, M.D. Electricity & Direct Water Consumption on Irish Pasture Based Dairy Farms: A Statistical Analysis. *Appl. Energy* **2018**, *210*, 529–537. [CrossRef]
121. Fiore, M.; Spada, A.; Contò, F.; Pellegrini, G. GHG and Cattle Farming: CO-Assessing the Emissions and Economic Performances in Italy. *J. Clean. Prod.* **2018**, *172*, 3704–3712. [CrossRef]
122. Vergote, T.L.I.; Vanrolleghem, W.J.; Van der Heyden, C.; De Dobbelaere, A.E.; Buysse, J.; Meers, E.; Volcke, E. Model-Based Analysis of Greenhouse Gas Emission Reduction Potential through Farm-Scale Digestion. *Biosyst. Eng.* **2019**, *181*, 157–172. [CrossRef]
123. Vergote, T.L.I.; Bodé, S.; De Dobbelaere, A.E.J.; Buysse, J.; Meers, E.; Volcke, E.I.P. Monitoring Methane and Nitrous Oxide Emissions from Digestate Storage Following Manure Mono-Digestion. *Biosyst. Eng.* **2020**, *196*, 159–171. [CrossRef]
124. Senga Kiessé, T.; Corson, M.S.; Eugène, M.; Aubin, J.; Wilfart, A. Analysis of Enteric Methane Emissions Due to Extreme Variations in Management Practices of Dairy-Production Systems. *Agric. Syst.* **2019**, *173*, 449–457. [CrossRef]
125. Skrydstrup, J.; Larsen, S.L.; Rygaard, M. Eco-Efficiency of Water and Wastewater Management in Food Production: A Case Study from a Large Dairy in Denmark. *J. Ind. Ecol.* **2020**, *24*, 1101–1112. [CrossRef]
126. Herzog, A.; Hörtenhuber, S.; Winckler, C.; Kral, I.; Zollitsch, W. Welfare Intervention and Environmental Impacts of Milk Production—Cradle-to-Farm-Gate Effects of Implementing Rubber Mats in Austrian Dairy Farms. *J. Clean. Prod.* **2020**, *277*, 123953. [CrossRef]
127. Dentler, J.; Kiefer, L.; Hummler, T.; Bahrs, E.; Elsaesser, M. The Impact of Low-Input Grass-Based and High-Input Confinement-Based Dairy Systems on Food Production, Environmental Protection and Resource Use. *Agroecol. Sustain. Food Syst.* **2020**, *44*, 1089–1110. [CrossRef]
128. Stanchev, P.; Vasilaki, V.; Egas, D.; Colon, J.; Ponsá, S.; Katsou, E. Multilevel Environmental Assessment of the Anaerobic Treatment of Dairy Processing Effluents in the Context of Circular Economy. *J. Clean. Prod.* **2020**, *261*, 121139. [CrossRef]

129. Bechini, L.; Costamagna, C.; Zavattaro, L.; Grignani, C.; Bijttebier, J.; Ruysschaert, G. Drivers and Barriers to Adopt Best Management Practices. Survey among Italian Dairy Farmers. *J. Clean. Prod.* **2020**, *245*, 118825. [CrossRef]
130. Fant, P.; Ramin, M.; Huhtanen, P. Replacement of Barley with Oats and Dehulled Oats: Effects on Milk Production, Enteric Methane Emissions, and Energy Utilization in Dairy Cows Fed a Grass Silage-Based Diet. *J. Dairy Sci.* **2021**, *104*, 12540–12552. [CrossRef] [PubMed]
131. Kirilova, E.; Vaklieva-Bancheva, N.; Vladova, R.; Petrova, T.; Ivanov, B.; Nikolova, D.; Dzhelil, Y. An Approach for a Sustainable Decision-Making in Product Portfolio Design of Dairy Supply Chain in Terms of Environmental, Economic and Social Criteria. *Clean Technol. Environ. Policy* **2022**, *24*, 213–227. [CrossRef]
132. Hodúr, C.; Nagypál, V.; Fazekas, Á.; Mikó, E. Blue and Gray Water Footprint of Some Hungarian Milking Parlors. *Water Pract. Technol.* **2022**, *17*, 1378–1389. [CrossRef]
133. Nagypál, V.; Mikó, E.; Hodúr, C. Sustainable Water Use Considering Three Hungarian Dairy Farms. *Sustainability* **2020**, *12*, 3145. [CrossRef]
134. Usva, K.; Virtanen, E.; Hyvärinen, H.; Nousiainen, J.; Sinkko, T.; Kurppa, S. Applying Water Scarcity Footprint Methodologies to Milk Production in Finland. *Int. J. Life Cycle Assess.* **2019**, *24*, 351–361. [CrossRef]
135. Murphy, E.; de Boer, I.J.M.; van Middelaar, C.E.; Holden, N.M.; Shalloo, L.; Curran, T.P.; Upton, J. Water Footprinting of Dairy Farming in Ireland. *J. Clean. Prod.* **2017**, *140*, 547–555. [CrossRef]
136. Drews, J.; Czycholl, I.; Krieter, J. A Life Cycle Assessment Study of Dairy Farms in Northern Germany: The Influence of Performance Parameters on Environmental Efficiency. *J. Environ. Manag.* **2020**, *273*, 111127. [CrossRef]
137. Iseppi, L.; Rosa, F.; Bassi, I. A Multi--Criteria Decision Approach for the Sustainable Dairy Farm Management. *Qual.—Access Success* **2022**, *23*, 242–252. [CrossRef]
138. Paterson, K.C.; Holden, N.M. Assessment of Policy Conflict Using Systems Thinking: A Case Study of Carbon Footprint Reduction on Irish Dairy Farms. *Environ. Sci. Policy* **2019**, *101*, 38–45. [CrossRef]
139. Metz, J.H.M.; Dijkstra, T.; Franken, P.; Frankena, K. Development and Application of a Protocol to Evaluate Herd Welfare in Dutch Dairy Farms. *Livest. Sci.* **2015**, *180*, 183–193. [CrossRef]
140. Vanhoudt, A.; Van Winden, S.; Fishwick, J.C.; Bell, N.J. Erratum to: Monitoring Cow Comfort and Rumen Health Indices in a Cubicle-Housed Herd with an Automatic Milking System: A Repeated Measures Approach. *Ir. Vet. J.* **2015**, *68*, 19. [CrossRef] [PubMed]
141. Humski, A.; Cvitković, D.; Bujanić, M.; Konjević, D.; Bačić, G.; Rudan, N.; Pavlak, M. Influence of Different Dairy Farming Systems on Milk Quality and Production. *Vet. Stanica* **2018**, *49*, 425–433.
142. Herzog, A.; Winckler, C.; Hörtenhuber, S.; Zollitsch, W. Environmental Impacts of Implementing Basket Fans for Heat Abatement in Dairy Farms. *Animal* **2021**, *15*, 100274. [CrossRef]
143. Martinsson, E.; Hansson, H. Adjusting Eco-Efficiency to Greenhouse Gas Emissions Targets at Farm Level—The Case of Swedish Dairy Farms. *J. Environ. Manag.* **2021**, *287*, 112313. [CrossRef] [PubMed]
144. Lahart, B.; Shalloo, L.; Herron, J.; O'Brien, D.; Fitzgerald, R.; Boland, T.M.; Buckley, F. Greenhouse Gas Emissions and Nitrogen Efficiency of Dairy Cows of Divergent Economic Breeding Index under Seasonal Pasture-Based Management. *J. Dairy Sci.* **2021**, *104*, 8039–8049. [CrossRef]
145. Zehetmeier, M.; Hoffmann, H.; Sauer, J.; Hofmann, G.; Dorfner, G.; O'Brien, D. A Dominance Analysis of Greenhouse Gas Emissions, Beef Output and Land Use of German Dairy Farms. *Agric. Syst.* **2014**, *129*, 55–67. [CrossRef]
146. Guerci, M.; Bava, L.; Zucali, M.; Tamburini, A.; Sandrucci, A. Effect of Summer Grazing on Carbon Footprint of Milk in Italian Alps: A Sensitivity Approach. *J. Clean. Prod.* **2014**, *73*, 236–244. [CrossRef]
147. Glenk, K.; Eory, V.; Colombo, S.; Barnes, A. Adoption of Greenhouse Gas Mitigation in Agriculture: An Analysis of Dairy Farmers' Perceptions and Adoption Behaviour. *Ecol. Econ.* **2014**, *108*, 49–58. [CrossRef]
148. Herron, J.; Hennessy, D.; Curran, T.P.; Moloney, A.; O'Brien, D. The Simulated Environmental Impact of Incorporating White Clover into Pasture-Based Dairy Production Systems. *J. Dairy Sci.* **2021**, *104*, 7902–7918. [CrossRef] [PubMed]
149. Gislon, G.; Ferrero, F.; Bava, L.; Borreani, G.; Prà, A.D.; Pacchioli, M.T.; Sandrucci, A.; Zucali, M.; Tabacco, E. Forage Systems and Sustainability of Milk Production: Feed Efficiency, Environmental Impacts and Soil Carbon Stocks. *J. Clean. Prod.* **2020**, *260*, 121012. [CrossRef]
150. Cecchini, L.; Torquati, B.; Paffarini, C.; Barbanera, M.; Foschini, D.; Chiorri, M. The Milk Supply Chain in Italy's Umbria Region: Environmental and Economic Sustainability. *Sustainability* **2016**, *8*, 728. [CrossRef]
151. Chen, W.; Holden, N.M. Bridging Environmental and Financial Cost of Dairy Production: A Case Study of Irish Agricultural Policy. *Sci. Total Environ.* **2018**, *615*, 597–607. [CrossRef] [PubMed]
152. Santolaya, J.L.; Lacasa, E.; Biedermann, A.; Muñoz, N. A Practical Methodology to Project the Design of More Sustainable Products in the Production Stage. *Res. Eng. Des.* **2019**, *30*, 539–558. [CrossRef]
153. Micha, E.; Heanue, K.; Hyland, J.J.; Hennessy, T.; Dillon, E.J.; Buckley, C. Sustainability Levels in Irish Dairy Farming: A Farm Typology According to Sustainable Performance Indicators. *Stud. Agric. Econ.* **2017**, *119*, 62–69. [CrossRef]
154. Jane Dillon, E.; Hennessy, T.; Buckley, C.; Donnellan, T.; Hanrahan, K.; Moran, B.; Ryan, M. Measuring Progress in Agricultural Sustainability to Support Policy-Making. *Int. J. Agric. Sustain.* **2016**, *14*, 31–44. [CrossRef]
155. Adenaeuer, L.; Breen, J.; Hayden, A. Insights in Overcoming the Non-Adoption of Voluntary Agricultural Ghg Mitigation Measures in Ireland. *Econ. Agro-Aliment.* **2020**, *22*, 1–26. [CrossRef]

156. Lehmann, J.O.; Mogensen, L.; Kristensen, T. Extended Lactations in Dairy Production: Economic, Productivity and Climatic Impact at Herd, Farm and Sector Level. *Livest. Sci.* **2019**, *220*, 100–110. [CrossRef]
157. Larkin, J.; Sheridan, H.; Finn, J.A.; Denniston, H.; Huallachain, D.O. Semi-Natural Habitats and Ecological Focus Areas on Cereal, Beef and Dairy Farms in Ireland. *Land Use Policy* **2019**, *88*, 104096. [CrossRef]
158. Pugesgaard, S.; Olesen, J.E.; Jorgensen, U.; Dalgaard, T. Biogas in Organic Agriculture—Effects on Productivity, Energy Self-Sufficiency and Greenhouse Gas Emissions. *Renew. Agric. Food Syst.* **2014**, *29*, 28–41. [CrossRef]
159. Silva, S.; Alçada-Almeida, L.; Dias, L.C. Development of a Web-Based Multi-Criteria Spatial Decision Support System for the Assessment of Environmental Sustainability of Dairy Farms. *Comput. Electron. Agric.* **2014**, *108*, 46–57. [CrossRef]
160. Fiorelli, J.-L.; Drouet, J.-L.; Duretz, S.; Gabrielle, B.; Graux, A.-I.; Blanfort, V.; Capitaine, M.; Cellier, P.; Soussana, J.-F. Evaluation of Greenhouse Gas Emissions and Design of Mitigation Options: A Whole Farm Approach Based on Farm Management Data and Mechanistic Models. *Int. J. Sustain. Dev.* **2014**, *17*, 22–34. [CrossRef]
161. Chen, X.; Corson, M.S. Influence of Emission-Factor Uncertainty and Farm-Characteristic Variability in LCA Estimates of Environmental Impacts of French Dairy Farms. *J. Clean. Prod.* **2014**, *81*, 150–157. [CrossRef]
162. Eory, V.; MacLeod, M.; Shrestha, S.; Roberts, D. Linking an Economic and a Life-Cycle Analysis Biophysical Model to Support Agricultural Greenhouse Gas Mitigation Policy. *Ger. J. Agric. Econ.* **2014**, *6*, 133–142.
163. Kiefer, L.; Menzel, F.; Bahrs, E. The Effect of Feed Demand on Greenhouse Gas Emissions and Farm Profitability for Organic and Conventional Dairy Farms. *J. Dairy Sci.* **2014**, *97*, 7564–7574. [CrossRef]
164. Chalmers, N.G.; Brander, M.; Revoredo-Giha, C. The Implications of Empirical and 1:1 Substitution Ratios for Consequential LCA: Using a 1% Tax on Whole Milk as an Illustrative Example. *Int. J. Life Cycle Assess.* **2015**, *20*, 1268–1276. [CrossRef]
165. Charlier, J.; Velde, F.V.; van der Voort, M.; Van Meensel, J.; Lauwers, L.; Cauberghe, V.; Vercruysse, J.; Claerebout, E. ECONOHEALTH: Placing Helminth Infections of Livestock in an Economic and Social Context. *Vet. Parasitol.* **2015**, *212*, 62–67. [CrossRef] [PubMed]
166. O'Brien, D.; Hennessy, T.; Moran, B.; Shalloo, L. Relating the Carbon Footprint of Milk from Irish Dairy Farms to Economic Performance. *J. Dairy Sci.* **2015**, *98*, 7394–7407. [CrossRef]
167. Van Middelaar, C.E.; Berentsen, P.B.M.; Dijkstra, J.; Van Arendonk, J.A.M.; De Boer, I.J.M. Effect of Feed-Related Farm Characteristics on Relative Values of Genetic Traits in Dairy Cows to Reduce Greenhouse Gas Emissions along the Chain. *J. Dairy Sci.* **2015**, *98*, 4889–4903. [CrossRef] [PubMed]
168. Dalla Riva, A.; Burek, J.; Kim, D.; Thoma, G.; Cassandro, M.; De Marchi, M. The Environmental Impact of Cow Milk in the Northeast of Italy. *Poljoprivreda* **2015**, *21*, 105–108. [CrossRef]
169. Robert Kiefer, L.; Menzel, F.; Bahrs, E. Integration of Ecosystem Services into the Carbon Footprint of Milk of South German Dairy Farms. *J. Environ. Manag.* **2015**, *152*, 11–18. [CrossRef]
170. Colombini, S.; Zucali, M.; Rapetti, L.; Crovetto, G.M.; Sandrucci, A.; Bava, L. Substitution of Corn Silage with Sorghum Silages in Lactating Cow Diets: In Vivo Methane Emission and Global Warming Potential of Milk Production. *Agric. Syst.* **2015**, *136*, 106–113. [CrossRef]
171. Chen, W.; White, E.; Holden, N.M. The Effect of Lameness on the Environmental Performance of Milk Production by Rotational Grazing. *J. Environ. Manag.* **2016**, *172*, 143–150. [CrossRef] [PubMed]
172. Soteriades, A.D.; Stott, A.W.; Moreau, S.; Charroin, T.; Blanchard, M.; Liu, J.; Faverdin, P. The Relationship of Dairy Farm Eco-Efficiency with Intensification and Self-Sufficiency. Evidence from the French Dairy Sector Using Life Cycle Analysis, Data Envelopment Analysis and Partial Least Squares Structural Equation Modelling. *PLoS ONE* **2016**, *11*, e0166445. [CrossRef]
173. Hammond, K.J.; Jones, A.K.; Humphries, D.J.; Crompton, L.A.; Reynolds, C.K. Effects of Diet Forage Source and Neutral Detergent Fiber Content on Milk Production of Dairy Cattle and Methane Emissions Determined Using GreenFeed and Respiration Chamber Techniques. *J. Dairy Sci.* **2016**, *99*, 7904–7917. [CrossRef] [PubMed]
174. Aggestam, V.; Buick, J. A Comparative Analysis of Vehicle-Related Greenhouse Gas Emissions between Organic and Conventional Dairy Production. *J. Dairy Res.* **2017**, *84*, 360–369. [CrossRef] [PubMed]
175. Green, A.; Lewis, K.A.; Tzilivakis, J.; Warner, D.J. Agricultural Climate Change Mitigation: Carbon Calculators as a Guide for Decision Making. *Int. J. Agric. Sustain.* **2017**, *15*, 645–661. [CrossRef]
176. Mu, W.; van Middelaar, C.E.; Bloemhof, J.M.; Engel, B.; de Boer, I.J.M. Benchmarking the Environmental Performance of Specialized Milk Production Systems: Selection of a Set of Indicators. *Ecol. Indic.* **2017**, *72*, 91–98. [CrossRef]
177. Salvador, S.; Corazzin, M.; Romanzin, A.; Bovolenta, S. Greenhouse Gas Balance of Mountain Dairy Farms as Affected by Grassland Carbon Sequestration. *J. Environ. Manag.* **2017**, *196*, 644–650. [CrossRef] [PubMed]
178. Green, A.; Tzilivakis, J.; Warner, D.J.; Lewis, K.A. Problems of Benchmarking Greenhouse Gas Emissions in Dairy Agriculture. *Benchmarking* **2017**, *24*, 1470–1489. [CrossRef]
179. Chen, W.; Holden, N.M. Social Life Cycle Assessment of Average Irish Dairy Farm. *Int. J. Life Cycle Assess.* **2017**, *22*, 1459–1472. [CrossRef]
180. Eckert, M.; Bell, M.; Potterton, S.; Craigon, J.; Saunders, N.; Wilcox, R.; Hunter, M.; Goodman, J.; Garnsworthy, P. Effect of Feeding System on Enteric Methane Emissions from Individual Dairy Cows on Commercial Farms. *Land* **2018**, *7*, 26. [CrossRef]
181. Lynch, J.; Skirvin, D.; Wilson, P.; Ramsden, S. Integrating the Economic and Environmental Performance of Agricultural Systems: A Demonstration Using Farm Business Survey Data and Farmscoper. *Sci. Total Environ.* **2018**, *628–629*, 938–946. [CrossRef] [PubMed]

182. Vellinga, T.V.; de Vries, M. Effectiveness of Climate Change Mitigation Options Considering the Amount of Meat Produced in Dairy Systems. *Agric. Syst.* **2018**, *162*, 136–144. [CrossRef]
183. Schmithausen, A.J.; Trimborn, M.; Büscher, W. Sources of Nitrous Oxide and Other Climate Relevant Gases on Surface Area in a Dairy Free Stall Barn with Solid Floor and Outside Slurry Storage. *Atmos. Environ.* **2018**, *178*, 41–48. [CrossRef]
184. Bittante, G.; Cipolat-Gotet, C. Direct and Indirect Predictions of Enteric Methane Daily Production, Yield, and Intensity per Unit of Milk and Cheese, from Fatty Acids and Milk Fourier-Transform Infrared Spectra. *J. Dairy Sci.* **2018**, *101*, 7219–7235. [CrossRef]
185. Bell, M.J.; Wilson, P. Estimated Differences in Economic and Environmental Performance of Forage-Based Dairy Herds across the UK. *Food Energy Secur.* **2018**, *7*, e00127. [CrossRef]
186. Syp, A.; Osuch, D. Assessing Greenhouse Gas Emissions from Conventional Farms Based on the Farm Accountancy Data Network. *Pol. J. Environ. Stud.* **2018**, *27*, 1261–1268. [CrossRef]
187. Soteriades, A.D.; Gonzalez-Mejia, A.M.; Styles, D.; Foskolos, A.; Moorby, J.M.; Gibbons, J.M. Effects of High-Sugar Grasses and Improved Manure Management on the Environmental Footprint of Milk Production at the Farm Level. *J. Clean. Prod.* **2018**, *202*, 1241–1252. [CrossRef]
188. Cameron, L.; Chagunda, M.G.G.; Roberts, D.J.; Lee, M.A. A Comparison of Milk Yields and Methane Production from Three Contrasting High-Yielding Dairy Cattle Feeding Regimes: Cut-and-Carry, Partial Grazing and Total Mixed Ration. *Grass Forage Sci.* **2018**, *73*, 789–797. [CrossRef]
189. Morais, T.G.; Teixeira, R.F.M.; Rodrigues, N.R.; Domingos, T. Carbon Footprint of Milk from Pasture-Based Dairy Farms in Azores, Portugal. *Sustainability* **2018**, *10*, 3658. [CrossRef]
190. Sharma, P.; Humphreys, J.; Holden, N.M. The Environmental Impact of Dairy Production on Poorly Drained Soils under Future Climate Scenarios for Ireland. *J. Environ. Manag.* **2018**, *223*, 625–632. [CrossRef]
191. Sharma, P.; Humphreys, J.; Holden, N.M. Environmental Impacts of Alternative Agricultural Uses of Poorly Drained Farm Land in Ireland. *Sci. Total Environ.* **2018**, *637–638*, 120–131. [CrossRef] [PubMed]
192. Doltra, J.; Villar, A.; Moros, R.; Salcedo, G.; Hutchings, N.J.; Kristensen, I.S. Forage Management to Improve On-Farm Feed Production, Nitrogen Fluxes and Greenhouse Gas Emissions from Dairy Systems in a Wet Temperate Region. *Agric. Syst.* **2018**, *160*, 70–78. [CrossRef]
193. Sharma, P.; Humphreys, J.; Holden, N.M. The Effect of Local Climate and Soil Drainage on the Environmental Impact of Grass-Based Milk Production. *Int. J. Life Cycle Assess.* **2018**, *23*, 26–40. [CrossRef]
194. Mostert, P.F.; van Middelaar, C.E.; Bokkers, E.A.M.; de Boer, I.J.M. The Impact of Subclinical Ketosis in Dairy Cows on Greenhouse Gas Emissions of Milk Production. *J. Clean. Prod.* **2018**, *171*, 773–782. [CrossRef]
195. Chen, W.; Holden, N.M. Tiered Life Cycle Sustainability Assessment Applied to a Grazing Dairy Farm. *J. Clean. Prod.* **2018**, *172*, 1169–1179. [CrossRef]
196. Schmithausen, A.J.; Schiefler, I.; Trimborn, M.; Gerlach, K.; Südekum, K.-H.; Pries, M.; Büscher, W. Quantification of Methane and Ammonia Emissions in a Naturally Ventilated Barn by Using Defined Criteria to Calculate Emission Rates. *Animals* **2018**, *8*, 75. [CrossRef]
197. Garnsworthy, P.C.; Difford, G.F.; Bell, M.J.; Bayat, A.R.; Huhtanen, P.; Kuhla, B.; Lassen, J.; Peiren, N.; Pszczola, M.; Sorg, D.; et al. Comparison of Methods to Measure Methane for Use in Genetic Evaluation of Dairy Cattle. *Animals* **2019**, *9*, 837. [CrossRef] [PubMed]
198. Soteriades, A.D.; Foskolos, A.; Styles, D.; Gibbons, J.M. Diversification Not Specialization Reduces Global and Local Environmental Burdens from Livestock Production. *Environ. Int.* **2019**, *132*, 104837. [CrossRef] [PubMed]
199. Eugène, M.; Sauvant, D.; Nozière, P.; Viallard, D.; Oueslati, K.; Lherm, M.; Mathias, E.; Doreau, M. A New Tier 3 Method to Calculate Methane Emission Inventory for Ruminants. *J. Environ. Manag.* **2019**, *231*, 982–988. [CrossRef]
200. Edouard, N.; Charpiot, A.; Robin, P.; Lorinquer, E.; Dollé, J.-B.; Faverdin, P. Influence of Diet and Manure Management on Ammonia and Greenhouse Gas Emissions from Dairy Barns. *Animal* **2019**, *13*, 2903–2912. [CrossRef] [PubMed]
201. Mosnier, C.; Britz, W.; Julliere, T.; De Cara, S.; Jayet, P.-A.; Havlík, P.; Frank, S.; Mosnier, A. Greenhouse Gas Abatement Strategies and Costs in French Dairy Production. *J. Clean. Prod.* **2019**, *236*, 117589. [CrossRef]
202. Lenerts, A.; Popluga, D.; Naglis-Liepa, K. Benchmarking the GHG Emissions Intensities of Crop and Livestock–Derived Agricultural Commodities Produced in Latvia. *Agron. Res.* **2019**, *17*, 1942–1952. [CrossRef]
203. Danielsson, R.; Lucas, J.; Dahlberg, J.; Ramin, M.; Agenäs, S.; Bayat, A.-R.; Tapio, I.; Hammer, T.; Roslin, T. Compound- And Context-Dependent Effects of Antibiotics on Greenhouse Gas Emissions from Livestock. *R. Soc. Open Sci.* **2019**, *6*, 182049. [CrossRef] [PubMed]
204. Hoekstra, N.J.; Schulte, R.P.O.; Forrestal, P.J.; Hennessy, D.; Krol, D.J.; Lanigan, G.J.; Müller, C.; Shalloo, L.; Wall, D.P.; Richards, K.G. Scenarios to Limit Environmental Nitrogen Losses from Dairy Expansion. *Sci. Total Environ.* **2020**, *707*, 134606. [CrossRef]
205. Berton, M.; Bittante, G.; Zendri, F.; Ramanzin, M.; Schiavon, S.; Sturaro, E. Environmental Impact and Efficiency of Use of Resources of Different Mountain Dairy Farming Systems. *Agric. Syst.* **2020**, *181*, 102806. [CrossRef]
206. Laca, A.; Gómez, N.; Laca, A.; Díaz, M. Overview on GHG Emissions of Raw Milk Production and a Comparison of Milk and Cheese Carbon Footprints of Two Different Systems from Northern Spain. *Environ. Sci. Pollut. Res.* **2020**, *27*, 1650–1666. [CrossRef]
207. Baldini, M.; Da Borso, F.; Rossi, A.; Taverna, M.; Bovolenta, S.; Piasentier, E.; Corazzin, M. Environmental Sustainability Assessment of Dairy Farms Rearing the Italian Simmental Dual-purpose Breed. *Animals* **2020**, *10*, 296. [CrossRef]

208. Depping, V.; Grunow, M.; Kulozik, U. A Methodological Framework for Comparing Fractionated and Non-Fractionated Products in Life Cycle Assessments: The Case of Milk Concentrates. *J. Clean. Prod.* **2020**, *257*, 120478. [CrossRef]
209. Hoang, D.L.; Davis, C.; Moll, H.C.; Nonhebel, S. Impacts of Biogas Production on Nitrogen Flows on Dutch Dairy System: Multiple Level Assessment of Nitrogen Indicators within the Biogas Production Chain. *J. Ind. Ecol.* **2020**, *24*, 665–680. [CrossRef]
210. González-Recio, O.; López-Paredes, J.; Ouatahar, L.; Charfeddine, N.; Ugarte, E.; Alenda, R.; Jiménez-Montero, J.A. Mitigation of Greenhouse Gases in Dairy Cattle via Genetic Selection: 2. Incorporating Methane Emissions into the Breeding Goal. *J. Dairy Sci.* **2020**, *103*, 7210–7221. [CrossRef]
211. Ramayo-Caldas, Y.; Zingaretti, L.; Popova, M.; Estellé, J.; Bernard, A.; Pons, N.; Bellot, P.; Mach, N.; Rau, A.; Roume, H.; et al. Identification of Rumen Microbial Biomarkers Linked to Methane Emission in Holstein Dairy Cows. *J. Anim. Breed. Genet.* **2020**, *137*, 49–59. [CrossRef]
212. Schönleben, M.; Mentschel, J.; Strelec, L. Towards Smart Dairy Nutrition: Improving Sustainability and Economics of Dairy Production. *Czech J. Anim. Sci.* **2020**, *65*, 153–161. [CrossRef]
213. Jonova, S.; Ilgaza, A.; Zolovs, M.; Balins, A. Impact of Inulin and Yeast Containing Synbiotic on Calves' Productivity and Greenhouse Gas Production. *Vet. World* **2020**, *13*, 1017–1024. [CrossRef]
214. Melin, M.; Barth, H. Value Stream Mapping for Sustainable Change at a Swedish Dairy Farm. *Int. J. Environ. Waste Manag.* **2020**, *25*, 130–140. [CrossRef]
215. Kiesse, T.S.; Corson, M.S.; LE Galludec, G.; Wilfart, A. Sensitivity of Greenhouse Gas Emissions to Extreme Differences in Forage Production of Dairy Farms. *Livest. Sci.* **2020**, *232*, 103906. [CrossRef]
216. Grassauer, F.; Herndl, M.; Nemecek, T.; Guggenberger, T.; Fritz, C.; Steinwidder, A.; Zollitsch, W. Eco-Efficiency of Farms Considering Multiple Functions of Agriculture: Concept and Results from Austrian Farms. *J. Clean. Prod.* **2021**, *297*, 126662. [CrossRef]
217. Berton, M.; Bovolenta, S.; Corazzin, M.; Gallo, L.; Pinterits, S.; Ramanzin, M.; Ressi, W.; Spigarelli, C.; Zuliani, A.; Sturaro, E. Environmental Impacts of Milk Production and Processing in the Eastern Alps: A "Cradle-to-Dairy Gate" LCA Approach. *J. Clean. Prod.* **2021**, *303*, 127056. [CrossRef]
218. de Haas, Y.; Veerkamp, R.F.; de Jong, G.; Aldridge, M.N. Selective Breeding as a Mitigation Tool for Methane Emissions from Dairy Cattle. *Animal* **2021**, *15*, 100294. [CrossRef] [PubMed]
219. Menardo, S.; Lanza, G.; Berg, W. The Effect of Diet and Farm Management on N2o Emissions from Dairy Farms Estimated from Farm Data. *Agriculture* **2021**, *11*, 654. [CrossRef]
220. Lambotte, M.; De Cara, S.; Brocas, C.; Bellassen, V. Carbon Footprint and Economic Performance of Dairy Farms: The Case of Protected Designation of Origin Farms in France. *Agric. Syst.* **2021**, *186*, hal-03021963. [CrossRef]
221. Bava, L.; Sandrucci, A.; Zucali, M.; Guerci, M.; Tamburini, A. How Can Farming Intensification Affect the Environmental Impact of Milk Production? *J. Dairy Sci.* **2014**, *97*, 4579–4593. [CrossRef]
222. Chmelíková, L.; Schmid, H.; Anke, S.; Hülsbergen, K.-J. Nitrogen-Use Efficiency of Organic and Conventional Arable and Dairy Farming Systems in Germany. *Nutr. Cycl. Agroecosystems* **2021**, *119*, 337–354. [CrossRef]
223. Herron, J.; O'Brien, D.; Shalloo, L. Life Cycle Assessment of Pasture-Based Dairy Production Systems: Current and Future Performance. *J. Dairy Sci.* **2022**, *105*, 5849–5869. [CrossRef]
224. Jebari, A.; Álvaro-Fuentes, J.; Pardo, G.; Batalla, I.; Martín, J.A.R.; Del Prado, A. Effect of Dairy Cattle Production Systems on Sustaining Soil Organic Carbon Storage in Grasslands of Northern Spain. *Reg. Environ. Change* **2022**, *22*, 67. [CrossRef]
225. Pierik, M.E.; Gusmeroli, F.; Marianna, G.D.; Tamburini, A.; Bocchi, S. Meadows Species Composition, Biodiversity and Forage Value in an Alpine District: Relationships with Environmental and Dairy Farm Management Variables. *Agric. Ecosyst. Environ.* **2017**, *244*, 14–21. [CrossRef]
226. Di Felice, V.; De Jesus Soares Bessa Batista, E.R.; Mancinelli, R.; Ferreira Batista, J.G.; Campiglia, E. Rurality and Agroecosystem Sustainability: A Case Study at Farm-Field Level in Terceira Island (Portugal) and in Viterbo Province (Italy). *Renew. Agric. Food Syst.* **2014**, *29*, 265–276. [CrossRef]
227. Pergola, M.; Piccolo, A.; Palese, A.M.; Ingrao, C.; Di Meo, V.; Celano, G. A Combined Assessment of the Energy, Economic and Environmental Issues Associated with on-Farm Manure Composting Processes: Two Case Studies in South of Italy. *J. Clean. Prod.* **2018**, *172*, 3969–3981. [CrossRef]
228. Dolman, M.A.; Sonneveld, M.P.W.; Mollenhorst, H.; De Boer, I.J.M. Benchmarking the Economic, Environmental and Societal Performance of Dutch Dairy Farms Aiming at Internal Recycling of Nutrients. *J. Clean. Prod.* **2014**, *73*, 245–252. [CrossRef]
229. Gullstrand, J.; De Blander, R.; Waldo, S. The Influence of Biodiversity Provision on the Cost Structure of Swedish Dairy Farming. *J. Agric. Econ.* **2014**, *65*, 87–111. [CrossRef]
230. Mihailescu, E.; Murphy, P.N.C.; Ryan, W.; Casey, I.A.; Humphreys, J. Phosphorus Balance and Use Efficiency on 21 Intensive Grass-Based Dairy Farms in the South of Ireland. *J. Agric. Sci.* **2015**, *153*, 520–537. [CrossRef] [PubMed]
231. de Vries, M.; Bokkers, E.A.M.; van Reenen, C.G.; Engel, B.; van Schaik, G.; Dijkstra, T.; de Boer, I.J.M. Housing and Management Factors Associated with Indicators of Dairy Cattle Welfare. *Prev. Vet. Med.* **2015**, *118*, 80–92. [CrossRef] [PubMed]
232. De Graaf, S.; Ampe, B.; Tuyttens, F.A.M. Assessing Dairy Cow Welfare at the Beginning and End of the Indoor Period Using the Welfare Quality®Protocol. *Anim. Welf.* **2017**, *26*, 213–221. [CrossRef]

233. Ragkos, A.; Abraham, E.M.; Papadopoulou, A.; Kyriazopoulos, A.P.; Parissi, Z.M.; Hadjigeorgiou, I. Effects of European Union Agricultural Policies on the Sustainability of Grazingland Use in a Typical Greek Rural Area. *Land Use Policy* **2017**, *66*, 196–204. [CrossRef]
234. Schader, C.; Drapela, T.; Markut, T.; Meier, M.S.; Lindenthal, T.; Hörtenhuber, S.; Pfiffner, L. Farm- and Product-Level Biodiversity Assessment of Conventional and Organic Dairy Production in Austria. *Int. J. Biodivers. Sci. Ecosyst. Serv. Manag.* **2014**, *10*, 20–39. [CrossRef]
235. Pornaro, C.; Spigarelli, C.; Pasut, D.; Ramanzin, M.; Bovolenta, S.; Sturaro, E.; Macolino, S. Plant Biodiversity of Mountain Grasslands as Influenced by Dairy Farm Management in the Eastern Alps. *Agric. Ecosyst. Environ.* **2021**, *320*, 107583. [CrossRef]
236. Verhagen, W.; van der Zanden, E.H.; Strauch, M.; van Teeffelen, A.J.A.; Verburg, P.H. Optimizing the Allocation of Agri-Environment Measures to Navigate the Trade-Offs between Ecosystem Services, Biodiversity and Agricultural Production. *Environ. Sci. Policy* **2018**, *84*, 186–196. [CrossRef]
237. Pilvere, I.; Nipers, A.; Pilvere, A. Evaluation of the European Green Deal Policy in the Context of Agricultural Support Payments in Latvia. *Agriculture* **2022**, *12*, 2028. [CrossRef]
238. Faccioni, G.; Sturaro, E.; Ramanzin, M.; Bernués, A. Socio-Economic Valuation of Abandonment and Intensification of Alpine Agroecosystems and Associated Ecosystem Services. *Land Use Policy* **2019**, *81*, 453–462. [CrossRef]
239. Van Middelaar, C.E.; Dijkstra, J.; Berentsen, P.B.M.; De Boer, I.J.M. Cost-Effectiveness of Feeding Strategies to Reduce Greenhouse Gas Emissions from Dairy Farming. *J. Dairy Sci.* **2014**, *97*, 2427–2439. [CrossRef] [PubMed]
240. Syrůček, J.; Bartoň, L.; Řehák, D.; Kvapilík, J.; Burdych, J. Evaluation of Economic Indicators for Czech Dairy Farms. *Agric. Econ. Czech Repub.* **2019**, *65*, 499–508. [CrossRef]
241. Chetroiu, R.; Cișmileanu, A.E.; Cofas, E.; Petre, I.L.; Rodino, S.; Dragomir, V.; Marin, A.; Turek-Rahoveanu, P.A. Assessment of the Relations for Determining the Profitability of Dairy Farms, A Premise of Their Economic Sustainability. *Sustainability* **2022**, *14*, 7466. [CrossRef]
242. Shalloo, L.; Hanrahan, L. Setting Targets for the Irish Dairy Industry. *Anim. Prod. Sci.* **2019**, *60*, 159–163. [CrossRef]
243. Lebacq, T.; Baret, P.V.; Stilmant, D. Role of Input Self-Sufficiency in the Economic and Environmental Sustainability of Specialised Dairy Farms. *Animal* **2015**, *9*, 544–552. [CrossRef] [PubMed]
244. Krupová, Z.; Krupa, E.; Michaličková, M.; Zavadilová, L.; Kadlečík, O. Economic Sustainability of the Local Dual-Purpose Cattle. *Poljoprivreda* **2015**, *21*, 220–223. [CrossRef]
245. Bassi, I.; Iseppi, L.; Nassivera, F.; Peccol, E.; Cisilino, F. Alpine Agriculture Today: Evidence from the Italian Alps. *Qual.—Access Success* **2020**, *21*, 122–127.
246. Pavić, L.; Turk, J.; Grgić, I.; Prišenk, J. Impact Analysis of the Young Farmers' Support Program on Slovenian Dairy Sector Development Using Econometric Modeling Approach. *Agronomy* **2020**, *10*, 429. [CrossRef]
247. Paracchini, M.L.; Bulgheroni, C.; Borreani, G.; Tabacco, E.; Banterle, A.; Bertoni, D.; Rossi, G.; Parolo, G.; Origgi, R.; De Paola, C. A Diagnostic System to Assess Sustainability at a Farm Level: The SOSTARE Model. *Agric. Syst.* **2015**, *133*, 35–53. [CrossRef]
248. Hoischen-Taubner, S.; Habel, J.; Uhlig, V.; Schwabenbauer, E.-M.; Rumphorst, T.; Ebert, L.; Möller, D.; Sundrum, A. The Whole and the Parts—A New Perspective on Production Diseases and Economic Sustainability in Dairy Farming. *Sustainability* **2021**, *13*, 9044. [CrossRef]
249. Skevas, I.; Zhu, X.; Shestalova, V.; Emvalomatis, G. The Impact of Agri-Environmental Policies and Production Intensification on the Environmental Performance of Dutch Dairy Farms. *J. Agric. Resour. Econ.* **2018**, *43*, 423–440.
250. Methorst, R.; Roep, D.; Verstegen, J.; Wiskerke, J.S.C. Three-Fold Embedding: Farm Development in Relation to Its Socio-Material Context. *Sustainability* **2017**, *9*, 1677. [CrossRef]
251. Verhees, F.; Malak-Rawlikowska, A.; Stalgiene, A.; Kuipers, A.; Klopčič, M. Dairy Farmers' Business Strategies in Central and Eastern Europe Based on Evidence from Lithuania, Poland and Slovenia. *Ital. J. Anim. Sci.* **2018**, *17*, 755–766. [CrossRef]
252. Läpple, D.; Thorne, F. The Role of Innovation in Farm Economic Sustainability: Generalised Propensity Score Evidence from Irish Dairy Farms. *J. Agric. Econ.* **2019**, *70*, 178–197. [CrossRef]
253. Grassauer, F.; Herndl, M.; Nemecek, T.; Fritz, C.; Guggenberger, T.; Steinwidder, A.; Zollitsch, W. Assessing and Improving Eco-Efficiency of Multifunctional Dairy Farming: The Need to Address Farms' Diversity. *J. Clean. Prod.* **2022**, *338*, 130627. [CrossRef]
254. Galliano, D.; Siqueira, T.T.S. Organizational Design and Environmental Performance: The Case of French Dairy Farms. *J. Environ. Manag.* **2021**, *278*, 111408. [CrossRef]
255. Duval, J.E.; Bareille, N.; Madouasse, A.; De Joybert, M.; Sjöström, K.; Emanuelson, U.; Bonnet-Beaugrand, F.; Fourichon, C. Evaluation of the Impact of a Herd Health and Production Management Programme in Organic Dairy Cattle Farms: A Process Evaluation Approach. *Animal* **2018**, *12*, 1475–1483. [CrossRef] [PubMed]
256. Ohm, M.; Schüler, M.; Warnecke, S.; Paulsen, H.M.; Rahmann, G. Measurement Methods on Pastures and Their Use in Environmental Life-Cycle Assessment. *Org. Agric.* **2014**, *4*, 325–329. [CrossRef]
257. Scotton, M.; Sicher, L.; Kasal, A. Semi-Natural Grasslands of the Non Valley (Eastern Italian Alps): Agronomic and Environmental Value of Traditional and New Alpine Hay-Meadow Types. *Agric. Ecosyst. Environ.* **2014**, *197*, 243–254. [CrossRef]
258. Pacini, G.C.; Merante, P.; Lazzerini, G.; Van Passel, S. Increasing the Cost-Effectiveness of EU Agri-Environment Policy Measures through Evaluation of Farm and Field-Level Environmental and Economic Performance. *Agric. Syst.* **2015**, *136*, 70–78. [CrossRef]

259. Cui, J.; Askari, M.S.; Holden, N.M. Grassland Soil Carbon and Nitrogen Stocks under Temperate Livestock Grazing. *Soil Res.* **2015**, *53*, 485–493. [CrossRef]
260. Zuliani, A.; Romanzin, A.; Corazzin, M.; Salvador, S.; Abrahantes, J.C.; Bovolenta, S. Welfare Assessment in Traditional Mountain Dairy Farms: Above and beyond Resource-Based Measures. *Anim. Welf.* **2017**, *26*, 203–211. [CrossRef]
261. O'Connor, A.H.; Bokkers, E.A.M.; de Boer, I.J.M.; Hogeveen, H.; Sayers, R.; Byrne, N.; Ruelle, E.; Shalloo, L. Associating Cow Characteristics with Mobility Scores in Pasture-Based Dairy Cows. *J. Dairy Sci.* **2019**, *102*, 8332–8342. [CrossRef] [PubMed]
262. Crossley, R.E.; Bokkers, E.A.M.; Browne, N.; Sugrue, K.; Kennedy, E.; Conneely, M. Risk Factors Associated with Indicators of Dairy Cow Welfare during the Housing Period in Irish, Spring-Calving, Hybrid Pasture-Based Systems. *Prev. Vet. Med.* **2022**, *208*, 105760. [CrossRef] [PubMed]
263. Scheurich, A.; Penicka, A.; Hörtenhuber, S.; Lindenthal, T.; Quendler, E.; Zollitsch, W. Elements of Social Sustainability among Austrian Hay Milk Farmers: Between Satisfaction and Stress. *Sustainability* **2021**, *13*, 13010. [CrossRef]
264. Gebska, M.; Grontkowska, A.; Swiderek, W.; Golebiewska, B. Farmer Awareness and Implementation of Sustainable Agriculture Practices in Different Types of Farms in Poland. *Sustainability* **2020**, *12*, 8022. [CrossRef]
265. Haas, R.; Schnepps, A.; Pichler, A.; Meixner, O. Cow Milk versus Plant-Based Milk Substitutes: A Comparison of Product Image and Motivational Structure of Consumption. *Sustainability* **2019**, *11*, 5046. [CrossRef]
266. Swagemakers, P.; Garcia, M.D.D.; Torres, A.O.; Oostindie, H.; Groot, J.C.J. A Values-Based Approach to Exploring Synergies between Livestock Farming and Landscape Conservation in Galicia (Spain). *Sustainability* **2017**, *9*, 1987. [CrossRef]
267. Triste, L.; Debruyne, L.; Vandenabeele, J.; Marchand, F.; Lauwers, L. Communities of Practice for Knowledge Co-Creation on Sustainable Dairy Farming: Features for Value Creation for Farmers. *Sustain. Sci.* **2018**, *13*, 1427–1442. [CrossRef]
268. Varela-Ortega, C.; Blanco-Gutiérrez, I.; Manners, R.; Detzel, A. Life Cycle Assessment of Animal-Based Foods and Plant-Based Protein-Rich Alternatives: A Socio-Economic Perspective. *J. Sci. Food Agric.* **2022**, *102*, 5111–5120. [CrossRef] [PubMed]
269. Montrasio, R.; Mattiello, S.; Zucaro, M.; Genovese, D.; Battaglini, L. The Perception of Ecosystem Services of Mountain Farming and of a Local Cheese: An Analysis for the Touristic Valorization of an Inner Alpine Area. *Sustainability* **2020**, *12*, 8017. [CrossRef]
270. Pachoud, C.; Da Re, R.; Ramanzin, M.; Bovolenta, S.; Gianelle, D.; Sturaro, E. Tourists and Local Stakeholders' Perception of Ecosystem Services Provided by Summer Farms in the Eastern Italian Alps. *Sustainability* **2020**, *12*, 1095. [CrossRef]
271. Beecher, M.; Ryan, A.; Gorman, M. Exploring Adolescents' Perceptions of Dairy Farming Careers in Ireland: Views of Students Studying Agricultural Science in Secondary School. *Ir. J. Agric. Food Res.* **2022**, *61*, 1–16. [CrossRef]
272. Gan, X.; Fernandez, I.C.; Guo, J.; Wilson, M.; Zhao, Y.; Zhou, B.; Wu, J. When to Use What: Methods for Weighting and Aggregating Sustainability Indicators. *Ecol. Indic.* **2017**, *81*, 491–502. [CrossRef]